COAL, IRON, AND OIL;

OR, THE

Practical American Miner.

A PLAIN AND POPULAR WORK ON

OUR MINES AND MINERAL RESOURCES,

AND A

Text-Book or Guide to their Economical Development.

With Numerous Maps and Engravings.

ILLUSTRATING AND EXPLAINING THE GEOLOGY, ORIGIN, AND FORMATION OF COAL, IRON, AND OIL, THEIR PECULIARITIES, CHARACTERS, AND GENERAL DISTRIBUTION, AND THE ECONOMY OF MINING MANUFACTURING, AND USING THEM; WITH GENERAL DESCRIPTIONS OF THE COAL-FIELDS AND COAL-MINES OF THE WORLD, AND SPECIAL DESCRIPTIONS OF THE ANTHRACITE FIELDS AND MINES OF PENNSYLVANIA AND THE BITUMINOUS FIELDS OF THE UNITED STATES,

THE IRON-DISTRICTS AND IRON-TRADE OF OUR COUNTRY, AND THE GEOLOGY AND DISTRIBUTION OF PETROLEUM, THE STATISTICS, EXTENT, PRODUCTION, AND TRADE IN COAL, IRON, AND OIL, AND SUCH USEFUL INFORMATION ON MINING AND MANUFACTURING MATTERS AS SCIENCE AND PRACTICAL EXPERIENCE HAVE DEVELOPED TO THE PRESENT TIME.

BY

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AUTHOR'S PREFACE.

I FEEL constrained to say a few brief words as a preface to the work which has just been completed, not in the spirit of egotism or to make excuses, but to ask for this book a candid and impartial hearing,—a full and just consideration of its theories, as well as its facts, before judgment is pronounced upon its merits collectively, or its individual idiosyncrasy.

The great body of the book treats on practical subjects, presenting facts as they exist, in palpable and unmistakable form. This matter is generally original, and was collected with much time and labor by both the author and the publisher, as well as by their agents; and on these there can be no difference of opinion; but in connection there are other subjects, which admit of many explanations and on which many theories exist.

In treating these subjects, I have selected, according to the best of my judgment, and adopted those which appear to be most consistent, without attacking those which are respectfully declined.

I have, however, adopted several new theories, which may be presented to the mind of the reader at first sight as strange and without support in fact. But I ask an impartial and patient examination, since the subjects presented are eminently worthy of consideration, and, if I am correct, no hasty decision can make them less true; while the examination of new theories on new and untrodden ground is, at least, as profitable as the discussion of old ones, which, though investigated from all points, still remain unsatisfactory and indefinite, and capable of numerous explanations, no two of which agree.

Three new and principal propositions are here set forth:—

First, *that the material forming both the Azoic and Palæozoic formations of the earth are almost exclusively and directly from volcanic sources.*

Second, *that volcanic and subterranean heat produced the vapors or gases which resulted in petroleum, naphtha, etc.*

Third, *that the hydro-carbons, in the shape of naphtha, petroleum, and their resulting bitumen, formed mineral coal.*

Nature has been a busy worker, and her creations are not as old as geology would make them. I was led to these conclusions irresistibly by the facts presented, after a careful and extensive practical examination, rather against my former opinions; but now that I have followed the NATURAL PROCESSES from point to point, and found *all* the coincidents to agree harmoniously without the necessity of calling miracle and phenomenon to my assistance, I do not hesitate to offer the foregoing "theories" as substantial facts; but for them I alone am responsible.

In preparing this work, Mr. Bannan, the associate author and publisher, has rendered valuable assistance in furnishing much of the data, in preparing many of the statistical tables, in reading and correcting proof, in furnishing liberally material aid, and by using every available means to expedite the work and make the book practical and valuable.

The copy and drawings have been produced by the writer, who is responsible for errors of omission and commission. I am aware of many such mistakes; but I have faithfully endeavored to be correct and consistent, and feel confident that the work will meet with a satisfactory reception from the candid and impartial reader.

S. H. D.

POTTSVILLE, January, 1866.

PUBLISHER'S PREFACE.

THE work which I have now the pleasure of introducing to the public has been long contemplated and promised; but the many difficulties of preparing a book of this character have delayed its publication to the present time, which perhaps may be the proper moment, since the demands and the promises of the future both require the work and encourage the realization of its precepts.

My own pressing and constantly-accumulating duties in conducting the publication of the "MINER'S JOURNAL" and an extensive business establishment, left no time to prepare and arrange the large amount of statistical and practical data on mining matters which has been collected in this office for the last thirty-five years; and I took the first opportunity to secure the services of a practical miner and engineer, in the person of Mr. Daddow, to assist me in presenting it in book form to the public.

In this work Mr. Daddow has elaborated the subject much beyond my original intention or expectation, and has become practically the author, since he has written all or most of the copy, and prepared all the sections, maps, and plans to illustrate the subjects presented. His practical experience in mining matters, and extensive acquaintance with all or most of the COAL, IRON, and OIL formations of this country, make him peculiarly fitted for the work; and I feel confident it will meet with general approbation.

In regard to the new theories presented, I do not commit myself positively; but, since nothing better than theory exists on those subjects, and none of the many theories agree or account for all the facts and coincidents, I feel like giving support to any new theory which promises better results, as I believe those herein presented do.

The main portion of the work, however, presents facts and such original information as we have been able to collect by an extensive canvass to the latest date. These cannot fail to be interesting and

instructive generally, and useful especially to the trades and operations represented.

While the cost of preparing, electrotyping, and issuing this book has much exceeded my estimates and expectations, I feel gratified in being able to present the first book ever published which presents in a practical manner both the extent and character of our mineral resources and the means of their development. Taylor's "Statistics of Coal," which is an eminently valuable and practical work, but now out of print, gives only a simple and partial statement of the extent of our coal-fields and their trades; and while Mr. Taylor was an accomplished and practical engineer, he did not pretend to give instructions in mining, or to trace and identify our coal-beds or the coal-fields.

The ponderous and costly volumes of our State Survey, by Prof. H. D. Rogers, contain a vast amount of useful information and scientific learning, but to the practical industry of our country they remain a dead letter. We have endeavored to be brief, plain, practical, and explicit, and to present facts without color or rhetorical flourish, and devoid of technicalities and mere scientific phrases when simple words would best express the meaning.

We hope thus to make the work popular, and as interesting and instructive to the general reader as useful and necessary to the miner, the manufacturer, and the mechanic. The book is, therefore, confidently offered to the public, not only to meet the demands of the times, but with a hope that it may inspire our people with a more consistent and uniform spirit in the development of our mineral resources and manufacturing industry.

B. B.

MINER'S JOURNAL OFFICE, POTTSVILLE, January, 1866.

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COAL, IRON, AND OIL;

OR,

THE PRACTICAL AMERICAN MINER.

CHAPTER I.

INTRODUCTION.

The Elements of National Wealth—Providences—Coal and Iron—A Comparison—The Value of Coal—Its Influence on Cities—New Castle—Pittsburg—Dynamic Value of Mineral Fuel—Its Effects on Industrial Resources—Production of the British Mines—Practical Illustrations—Manual Power and Endurance *vs.* Steam-Power—The Labor of Women in English Mines—Value of Slave Labor in Peace or War—Anthracite Coal of Pennsylvania—Its Value to our National Resources—Economy and Waste of Mining—Probable Exhaustion—Limited Supplies and Unlimited Demands—Striking Pictures—The Fall and Decline of the British Empire—Oil and Coal—Nature's Laboratories.

GOD, in his wonderful providence, has blessed our country, above all others, with the most magnificent profusion of mineral wealth. When compared with the most favored lands, where coal and iron are essential elements of national wealth and greatness, our country far surpasses them all in her exhaustless resources, not only of those great and controlling elements, but all the essentials to national strength and power which make an industrious people wealthy, prosperous, and respected.

In every aspect in which we view the wonderful resources of our country, we find cause for gratulation and admiration, whether we contemplate the productions of the soil, or the vast extent and richness of the mineral kingdom; the wide and varied scenes of its distribution, or the topographical features and facilities for its development. These resources, however, are rivalled by the physical proportions of the land which we cannot cease to laud and admire,—whose limits extend from ocean to ocean, and occupy one-eighth ($\frac{1}{8}$) of the habitable world, within the temperate zones.

We may be allowed to speculate a moment on the providence which preserved, throughout the darker ages, a land so evidently favored with all the natural blessings and provisions for the good and welfare of man.

We cannot fail to recognize that universal Wisdom which orders events from the beginning and provides for the destinies of nations before the era of their existence. With this faith as a foundation, we may justly hope to come out of our present day of trial and pain like gold tried in the fire; with the country we love united in one common destiny,—purer, richer, dearer for the incalculable price of precious blood and the immense amount of treasure it has cost us.

But our task is eminently a practical one, and we neither expect nor wish to indulge in speculative digressions. The work before us is one of fact and figure,—usually "dry" work; but we hope to make it interesting to the general reader, as well as useful to the professional and practical.

The distribution of coal and iron—and at the present day we must not omit oil—throughout North America, but more particularly the United States, is wonderfully general and impartial. On consulting the maps, it will be noticed that our coal deposits dot the features of this country from ocean to ocean, and in some cases their immense extent almost obscures the surface of entire States. Of our three million square miles of superficial area, the known deposits of coal occupy 200,000, or one-fifteenth ($\frac{1}{15}$) of the entire area; while the existence of other immense fields not yet explored is unmistakable.

In comparison with other coal-producing countries, this ranks not only first, but far superior in that respect to all others.

The United States has one square mile of coal to every 15 square miles of territory.

Great Britain has one for every 20 square miles of superficial area.

Belgium has one to every 22½ square miles of surface.

And France has one square mile of coal to every 200 square miles of territory.

The value of coal to those possessing and utilizing it is made manifest by their prosperity and the wealth and power of communities and nations whose economy is largely influenced by its trade or dynamic value.

England furnishes the most prominent instance; and English cities located on or near coal, or within its direct influence, flourish, while older and formerly more prominent places decline. We may mention Glasgow, Manchester, Birmingham, Leeds, Sheffield, and last, but not least, Newcastle-on-Tyne. To what can we attribute the astonishing growth of those cities, or the declining condition of Canterbury, Winchester, Salisbury, and other towns in the south of England, but to the presence or absence of coal?

But we need not look abroad for instances of its influence on cities and communities, when so many of our own cities and towns owe their growth and prosperity to the proximity or availability of coal. It is true that

other causes have, in many instances, given a wonderful impetus to the birth and growth of towns and cities in the New World. But as the true promoter of progressive and permanent development, coal is pre-eminently the first in value or dynamic effect of all our minerals, or the means of converting them to our use and comfort.

"If you would see what *coal* can do for a people who turn it to full account, look at Pittsburg, a city of 150,000 inhabitants, built up by its mines of coal. There are no drones in its hive; heads and hands are busy. It lost $30,000,000 by the Rebellion, without shaking its credit. No city on this continent contains more solid wealth in proportion to its population. Its prosperity is permanent, for it is based upon the creation of new values. Possessing in its coal the creative power, it stretches out its mighty arms and gathers the wealth of half a continent into its lap. It brings to its furnaces and forges the iron and copper of Lake Superior; glass-sand from New England, Missouri, and Illinois; lead from Wisconsin and Missouri; zinc, brass, and tin from beyond the seas. You pass through its gigantic establishments, and are amazed at the variety and extent of their perfected productions. Yet all these, from the most delicate fabric of glass to the ponderous cannon and steam-engine, are in the coal which underlies the smoky hills of Pittsburg."*

THE DYNAMIC VALUE OF COAL.

Rogers, in his Geology of Pennsylvania, has given a very curious statement of the force or power derived from the combustion of certain amounts of coal, which, while it presents an approximate estimate and conveys to the mind an idea of the mechanical force thus derived, is very erroneous in statement and fact. He estimates the average duty of the improved Cornish pumping-engine as equivalent to 100,000,000 pounds lifted one foot high by the consumption of one bushel, or 84 pounds, of coal, and then takes the maximum duty as 125,000,000 under the same circumstances. By dividing the bushel of 84 pounds into the maximum duty, 125,000,000, he makes one pound of coal raise 1,500,000 pounds one foot high, or equivalent to the labor of a strong man on the tread-mill during 10 hours; and thus he estimates that (4) four tons of coal is equal to twenty years of manual labor, or an average lifetime of hard work. By this ingenious estimate, 10,000,000 tons of coal are made to supply England each year with a mechanical force, as applied to the production of steam, equal to 3,500,000 fresh men laboring through 20 years.

We give this singular statement, not only for the purpose of correcting it,—since it has been widely circulated,—but to show that even a practical application of this force, as applied to mechanical effect, will increase the value of manual labor a hundredfold.

* Letter of Professor Daniels to the Chicago "Tribune."

The average "duty" of 35 Cornish pumping-engines at work in England during 1864 was 500,000 pounds lifted one foot high with a consumption of one pound of coal. But in an estimate of this character we cannot assume even the average consumption of the Cornish engine to be the rule, since the consumption of coal to the power produced, by the ordinary English engines, is at least double. We presume that 200,000 pounds lifted one foot high by the combustion of one pound of coal is nearer to the rule than the exception.

But we will place our figures still lower, and make 10 pounds of coal, as applied to the production of mechanical power through the agency of steam, as equal to a day's work, or 1½ tons of coal as equal to a year of manual labor. 10,000,000 tons of coal, thus applied, adds to the productive labor of England a force equal to the exertion of 7,500,000 fresh men annually!

The amount specified,—10,000,000 tons,—as used for the production of steam in England, is, perhaps, much below the actual consumption. It is estimated that 100,000,000 tons of coal were produced by the mines of Great Britain in 1864, or nearly 90,000,000, as sent from the mines. But all practical miners are aware that a large amount of coal is consumed at the mines.

In 1861 the production of the great northern coal-field, in Northumberland and Durham, was 21,777,570 tons. Of this amount, 19,077,570 tons were sold or sent from the mines, leaving 2,700,000 burned for home consumption and wasted at the mines. The same proportion used at the mines generally would swell the amount to over 100,000,000. This vast, almost incomprehensible, mass of coal has been produced by 300,000 men and boys at 3000 collieries.

In 1861 the number of collieries in Great Britain, and their production, were:—

England	2074	collieries	63,870,123	tons.
Wales	481	"	8,561,021	"
Scotland	424	"	11,081,000	"
Ireland	73	"	123,070	"
	3052	"	83,635,214	"

The number of collieries is constantly *decreasing*, though their productions are increasing. In 1860 there were 13 collieries more than in 1861, while the production of coal was one million of tons less.

The great northern coal-field, in Northumberland and Durham, is the greatest coal-producing district. In 1861 there were 271 collieries in operation, employing nearly 50,000 men and boys, while the production and distribution of coal from these collieries were:—

House coal, for domestic uses	4,493,450 tons.
Gas coal	1,717,000 "
Steam coal, small and manufacturing coal	4,317,120 "
Distributed on lines	2,300,000 "
Coke consumed in iron trade	5,000,000 "
Manufacturing	1,250,000 "
Colliery and home consumption	2,200,000 "
Waste at collieries	500,000 "
	21,777,570 "

The above is, perhaps, an average distribution of the English coals, and, it will be noticed, over one-fifth, or 5,000,000, of this amount,—included in steam, manufacturing, and line consumption,—is made use of for the production of steam. From this data we may safely estimate that one-tenth, or 10,000,000 tons, of the entire production of Great Britain is applied to mechanical purposes in labor-saving operations. The estimate, therefore, which makes the coal of England add to her resources of labor the equivalent of 7,500,000 strong men per annum, is not exaggerated.

In fact, when we consider the processes by which our forefathers elaborated their metals and produced their weapons of defence or articles of general utility with their "stone-hammers" and "water-blast," we can form a slight conception of the value of coal for other uses than the production of steam. It has been the great means of facilitating invention and progression,—the "*Philosopher's Stone*," which has turned all it touched to value or use.

Thus, the dynamic value of the coal which nature has stored up in our mountains is beyond calculation. The latent power which puts in motion the great forces of nature is heat; and the most available means of exerting that power, within the economy of nature, at the disposal of man, is in the carbon of our coal-beds.

We cannot dismiss this subject without giving a practical illustration of the value of coal in the production of steam as exerted in labor-saving machinery.

Not many years ago—as late as 1842–50—women were employed in the British collieries transporting coal from the mines to the surface. The loads they carried were almost incredible. In fact, the burdens could not be borne were not the bearers trained to the work from their infancy.

"We have seen a woman take on a load of at least 170 pounds avoirdupois, travel with this 150 yards up the slope of the coal, below ground; ascend a pit by stairs 117 feet, and travel up the hill 20 yards more to where the coal was laid down. All this she would perform no less than twenty-four times each day, traversing a distance of 5¾ miles in going and returning."* "It was reckoned nothing extraordinary at a Lothian colliery

* See Taylor's Statistics, page 214.

(Scotland) for a woman to carry on her back from 35 to 40 cwt. of coal each day a distance of between 300 and 400 yards, the greater part of the road being not higher than 4½ feet, and in some cases a considerable portion covered with water."

As late as 1850, it appears, a great number of women and girls were employed in some of the Welsh mines, though not for the purpose of carrying coals to the surface, yet perhaps in occupations equally laborious. It may be considered a hard day's work for any man, however strong, to convey the burdens of those women as described in the foregoing quotation,—that is, a load equal to two tons, of 2000 pounds each, carried an average distance of 300 yards horizontal, or 200 feet perpendicular. It would, therefore, require 700 men, thus employed, to transport the production of one of our large collieries, producing 500 tons per day, a distance of 600 feet perpendicular. But a steam-engine of 100 horse-power, using five tons of coal per day, will do the same work with ease.

Perhaps a still more practical and palpable illustration may be given of the value of mechanical force developed by the carbon of our coal, or, in other words, the vast addition to our industrial and national resources supplied by labor-saving machinery, steam, and mechanical skill.

The chief industrial or productive force of the Slave States was derived from the labor of their 4,000,000 of slaves. Of these, perhaps not more than 1,000,000 were productive as full-grown persons; or, the entire productive value of men, women, and children was equal to the labor of 1,000,000 full-grown men. This labor, as a rule, was exerted simply as brute force, without the assistance of skill or mechanical means, but represented a capital or valuation, according to Southern figures, of 2,000,000,000 dollars. The same amount of force would be exerted by 150,000 horse-power in steam machinery, costing, at $100 per horse-power, $15,000,000. Such an addition of force would be of tenfold more value to the 8,000,000 whites of the South than their slave-labor; or, if added to the slave-labor, under the intelligent development attainable by the slave, the productive power of the South would be increased a hundredfold, according to the degree of mechanical skill displayed and the uses to which the power is applied.

The secret of the rapid decay of Southern resources and means of defence is primarily in their lack of coal or their appreciation of its value. Had they developed their mineral resources, which are abundant, and increased their industrial or productive power by the mechanical force derived from the judicious use of coal and iron, those 12,000,000 people would never have rebelled; but, having rebelled, would never have been brought to submission.

The ability to produce iron in sufficient quantities to supply the wants of a nation under all circumstances of war or peace, constitutes an element

of strength never before so fully estimated or exemplified as in the present contest. Our ability to produce iron is equal to our wants, and, consequently, we make use of that element of strength to its fullest extent,—in the production of iron-clad ships, the fabrication of superior guns, the manufacture of the most effective small arms, and an unlimited supply of rails and rolling-stock, &c. &c. And not only have we the iron in abundance for all those purposes, but our *iron* and *coal* enable our mechanics to multiply their labor or productive ability over a hundredfold, as compared with the productive power of the unskilled brute labor of the South.

The amount of iron produced in the South since the commencement of the war has not only been deficient for ordinary purposes, but not equal to the requirements for the materials of war. No railroad iron has been produced for repairs or otherwise, and but little iron has been spared for the replacement of worn-out rolling-stock. The ability to produce iron, and the cost of its production, have both been on a par. All the iron produced in the South during the last four years, from '60 to '64, has been made with charcoal, either in the rude cold-blast furnace, using from eight to thirteen cords of wood to the ton of metal produced, or in the primitive Catalan hearth, with "water-blast," and, in some cases, the old "stone-hammer" of our ancestors who lived a thousand years ago.

For the production of one ton—2000 pounds—of wrought iron in the Catalan forge, under ordinary circumstances, 75 days' labor is required in the various processes; while the amount of labor required to produce a ton of iron at our improved rolling-mills does not exceed 20 days from the miner to the finisher. Nearly the same difference exists in the production of cast iron between the rude charcoal furnaces of the South and the improved anthracite furnaces of the North. The rebellion, therefore, lacked the permanent strength imparted by iron, and decayed rapidly in consequence. Had the Confederates the means and ability to build iron-clad rams in proportion to their numbers and mineral resources, our great superiority on the water would have been neutralized, and their cotton made available for war purposes. But, depending entirely on brute force, their resources and means of defence have depreciated in ratio with their loss of able-bodied men by whatever cause.

Virginia contains more coal than Pennsylvania: yet, though the oldest State, she has never made it available by development, and not one pound of her coal has been used for the production of iron in the blast furnace since the commencement of the war, and but a few tons before; the Richmond coal being too impure for such purposes. Tennessee was the only Southern State in which iron was made from mineral coal; and the production there ceased on the occupation of Chattanooga by the Federal forces.

In our description of the coal and iron regions of the Southern States, we will give the details of their mining and manufacturing status both

before and since the war. But the facts here presented forcibly illustrate the value of coal in peace or war.

We may boldly state that the anthracite coal of Pennsylvania has been our greatest source of strength, whether considered as augmenting in a hundredfold ratio our industrial resources in the mechanical line, or supplying the means and material of war, exclusive, of course, of the men and the money. But even these are influenced to a great extent by the strength imparted to our national resources through the dynamic agency of coal.

Philadelphia and New York, and all the manufacturing cities and towns of New England, have the greatest source of their productive power in the mountains of Pennsylvania.

Those anthracite basins represent but a spot in the coal area of the United States,—only 470 square miles of anthracite in a total area of 206,939 square miles. But its present available value is greater than the entire area of bituminous coal; and all, except the 470 square miles, is of that class, exclusive of a doubtful and unproductive field of 100 square miles in Massachusetts and Rhode Island.

Of the 22,000,000 tons reported as the coal production of 1864, nearly 10,000,000 tons were anthracite. But this vast preponderance cannot always exist in favor of the anthracite mines, when the Western coal-fields are more fully developed to meet the increasing wants of Western growth and improvement. The fact, however, that those anthracite fields are the only known or available deposit of the kind, and that the entire East and a portion of the Northwest, representing a population of over 12,000,000, draw most of their supplies of fuel from thence, and must continue to do so, will always attach superior importance and value to the anthracite coals of Pennsylvania.

We cannot make even an approximate estimate of their value to our resources; figures would scarcely convey an idea. We may calculate the production per acre, and jump at some conclusion concerning the amount per square mile; but the value of a ton of coal in the mountain, or the same amount in market, has no relation to its dynamic value in the production of mechanical force or motion, its necessity to our manufactures, its importance to the arts and sciences, or indirectly as a means of power and strength in peace or war. Yet its marketable value is no small item in our trade-lists, though comparatively of late development. Its growth or increase is unparalleled by any trade, except the oil trade of Western Pennsylvania; and the rapidly increasing demand for this class of fuel insures a permanent expansion of the trade, equal, perhaps, to the means of supply.

Though the area be small and insignificant, when compared on the map with the wide extent of our bituminous fields, the supply is practically

unlimited for all present purposes. A coal-seam five feet thick will produce 5000 tons of marketable coal, even under the present wasteful mode of mining. There can be no doubt of an average of 60 feet vertical thickness of available coal under the entire coal area of the anthracite fields. This would yield 60,000 tons per acre, or 18,000,000,000 in the 300,000 acres which they contain. But under a more careful system of mining, as practised in England and elsewhere, and which will be practised here when coal and coal lands are appreciated at their proper value, one-third more coal may be obtained from an acre of land than is given in the foregoing estimate. The amount of hard anthracite coal existing in an acre of land, as a maximum, is 1613 tons per foot of vertical thickness, or 96,780 tons per acre, according to the average estimate of 60 feet total vertical thickness. In the best English mines, from $\frac{1}{10}$ to $\frac{1}{14}$ of the coal is left or wasted in the pillars. Under the same system of mining, we might obtain nearly 90,000 tons of coal to the acre, or one-third more than our present system will admit of. But we can scarcely hope for the same degree of economy in operating our large veins.

The natural increase of the anthracite coal-trade is about $2\frac{1}{2}$ per cent. per annum; and we may anticipate even a larger increase on the pacification of the country, when an impetus will be given to our manufacturing interests far greater than that given by the war, under the protection of fostering tariffs and through the means of our vastly increased capital.

Our present production is 10,000,000 of tons per annum, and in all probability it will not be less than 15,000,000 in 1870. At this rate of increase we may live to see the day when our coal-trade will be 30,000,000 tons annually, and perhaps some of us may be able to count double that amount. But an annual drain of 30,000,000 from our limited area will exhaust the anthracite coal-fields in 600 years,—a small period in the life-time of a nation, and but little over our past existence. When compared with the years of England, France, or China, we find it a short time.

The amount we name is moderate as an estimate, and twenty years may not elapse before its realization. But our estimate does not cover the whole consumption by perhaps half the drain on our resources of anthracite. We may state, without exaggeration, that the drain or actual loss on the original supply since the commencement of the trade has not been less than 189,000,000 tons, or one-half more than the shipments of marketable coal; while our present production of 10,000,000 may be more fairly represented in the actual drain on our resources by 15,000,000 tons shipped, wasted, and lost.

The estimate is that one-third of the coal is left in the mine as inaccessible, lost in pillars, &c. The waste caused by our present mode of *crushing* through the "breaker" ranges from 15 to 20 per cent., and sometimes, under certain circumstances, it has exceeded 30 per cent.; and, in addition

to these two great items in the waste of our mines, we may mention the home and colliery consumption, which is, perhaps, from 5 to 10 per cent.

In order, therefore, to produce 30,000,000 annually, the drain on our mines or resources would be 45,000,000 under our present wasteful system of mining, since the loss in pillars, waste in fine, and colliery and home consumption, is not less than 53 per cent. of the whole production.

Should the anthracite trade ever approach the proportion of the English coal-trade, our supply would melt away in 180 years. It is not probable that such proportions will ever be assumed by this trade, in view of the vast extent of bituminous coal held in reserve, and the use of unlimited supplies of petroleum, which will usurp the place of the purest carbons in many instances. There are facts, however, in this connection, which justify us in assuming a large demand on the anthracite trade. The anthracite basins are the only large bodies of available coal east of the Alleghanies—excepting the small but valuable Broad Top coal, and a few other scattering semi-bituminous patches—accessible to the Eastern markets. It is not at all probable that our Western bituminous coal will ever take the place of a superior article for all ordinary purposes: therefore the great source of supply for the East will be in the anthracite coal-fields. The six New England States, New York, New Jersey, part of Pennsylvania, and a large extent of the South on the Atlantic board, must draw the chief portion of their supplies of fuel from thence. The area to be supplied with anthracite is, perhaps, not less than 300,000 square miles, and the present population 12,000,000. This is exclusive of a large trade which finds its way northwest to the great lakes and to Canada,—a trade constantly on the increase.

The area of England, Ireland, Scotland, and Wales is 121,000 square miles, as a home market for the consumption of 70,000,000 tons, or the British production, deducting the exports. The area of 300,000 square miles to which we refer on the Atlantic slopes can support a population to the square mile equally as dense as that of England.

Under such circumstances, a rapid and vast increase may be anticipated for the anthracite trade of Pennsylvania. The duration of this invaluable source of wealth, and the means by which it is economized, are questions of the greatest importance, not only to individuals but to the state and country at large; and we propose in the ensuing pages to present the "economy of mining" in a prominent manner and from the best practical sources.

The waste of the anthracite mines is a matter of astonishment to English mining engineers on flying visits to those regions. But, domiciled here, even professionally, they soon become indifferent to that which cannot be generally prevented, while the apparent abundance seems to promise an unlimited supply. We do not expect to present a correct

impression of this wanton waste, or create much interest in the matter under present circumstances.

But, having shown that the coal in those fields, which at present is considered inexhaustible, is, on the contrary, in process of rapid exhaustion, and but limited in proportion to the area and demand to be supplied, we will try to impress those interested with some conception of the great loss involved, both private and public, in the present waste of coal.

As we before mentioned, the waste is equal to the "vend." The value of the anthracite trade for 1864 is stated at 60,000,000 of dollars,—that is, its simple marketable or exchange value as a commodity; while its mechanical value, as affecting our productive ability, is still vastly greater in the scale of values.

But this item is one that must attract attention. If these coal deposits represent a body of 18,000,000,000 tons of workable coal, the loss of half, on the same basis of calculation, is one that those who own coal lands may be interested in figuring up when their abandoned mines may cease to yield them princely incomes.

ENGLAND AND HER RESOURCES.

The prosperity of England is involved in the duration of her coal-fields. The exhaustion of her mines must sap the foundation of her strength. The subject engages the attention of her people; and all available means are taken to economize this great and primary source of her prosperity and power.

It is estimated by the staticians of Great Britain, that their available supply of coal will be exhausted, under the present rate of consumption and increase, in 300 years from the present time.

A rather fanciful writer—the author of a little English book entitled "Our Coal and Our Coal-Pits"—thus expresses himself:—

"Without coal our steam-power would be annihilated, and with that our prosperity as a nation, and possibly our supremacy. Our steam-engines would rust unused, for lack of suitable fuel, our steam-vessels would be dismantled and decaying in dock, and all our processes of manufacture would be deteriorated; and the future historian of the revolutions of empires would date the decline and fall of the vast dominions of Britain from the period when her supplies of mineral fuel were exhausted and her last coal-field worked out.

"An ancient writer has drawn a picture of the exiled Marius sitting on the ruins of Carthage and musing and mourning in proud grief. A modern historian has drawn an equally striking picture of a New Zealander sitting and musing on the ruins of London at the debris of the fallen St. Paul's. It has been reserved for the author of this book to conceive the

picture of some one of his lineal posterity sitting on the top of the ruins of a great but exhausted New-Castle colliery, and mourning and moralizing over the fate of fallen Britain. Should such a picture ever be drawn, its subject will be more pathetic and powerful than that of proud Marius or the feathered New Zealander."

COAL AND IRON.

Our introduction has been rather disconnected and rambling. It has been our aim, however, to present the most practical and striking illustrations of the value of coal to the industrial resources of nations, and attract attention to the value of our coal-fields.

Our resources in iron are subordinate to that of coal: without a supply of mineral fuel, our deposits of iron ores would not be available. We have, therefore, given pre-eminence to coal; and in the ensuing pages we shall confine ourselves to a brief synopsis of our resources for the production of iron, as illustrating the value and uses of coal, with such information on the subject as may be necessary to present a concise review of the trade to make it interesting and valuable.

OIL, OR PETROLEUM.

No work on our mineral resources, and particularly mineral fuels, would be complete without a practical or theoretical notice of our great petroleum regions. To this end we have collected all the available information on the subject, and have not only made extensive examinations personally, but have availed ourselves of the practical experience of others. Petroleum contains the constituents of coal, or *vice versâ*. The one is solid, the other fluid. Both are formed principally of carbon and hydrogen; the one with earthy impurities, the other almost pure. We therefore look upon petroleum as a species of mineral fuel, the product principally of our coal-fields, enhancing their value, providing for their development, and, while it fills some of the uses to which coal has been applied, it increases the area of its distribution and enlarges the sphere of its usefulness.

In a rapid glance over the field of our researches,—our extensive fields of coal, our mountains and beds of ores, and our deep fountains of mineral oils,—we cannot fail to be impressed with admiration and wonder at those magnificent creations of Nature, when we reflect that they are the result of chemical action and combination carried on in her great laboratory.

The productions of vegetation, whose original magnificence and extent are beyond comprehension, has been preserved year after year, through numberless ages, in the most compact and available form for use. Unlimited beds of precious ores, and exhaustless fountains of invaluable oils,

are stored away by nature in the treasure-houses of our mineral kingdom. Those exhaustless sources of mineral wealth are not the result of common causes. *Ore*, *coal*, and *oil* are not formations resulting from the evident processes which we all comprehend, and such as we see in common rocks and slates; but they appear to be the concentrated wealth of all our lithological creations, separated and refined in the great laboratory of Nature, and stored carefully away in the "caves of the earth" for the use of her creatures.

There is something grand and wonderful in those great chemical processes which stored our earth with minerals, even though we speculate merely on their cause and effect. We can imagine the world of fire which rolled and struggled for vent in the bowels of the earth, the immeasurable volumes of gases which poured from these smouldering fires, the great volcanic crucibles and the oceanic cauldrons which Nature used, if we cannot comprehend the modes and laws of her great chemical operations. The results, however, we see and realize. They give to man the control of Nature's domain, and subject all her productions to his use and pleasure. A proper appreciation of her gifts and provisions for our use will make us "healthy, wealthy, and wise," and secure us peace, power, and prosperity.

PART I.

CHAPTER II.

GEOLOGY.

The Creation—Mosaic Periods—Geological Structure—Igneous Rocks—Metamorphic Strata—Palæozoic Formations—Vertical Column—Primal Strata—Limestones—The Great Appalachian Valley and Appalachian Mountains—The Oil Strata—Old Red Sandstone—Subcarboniferous—The False Coal Measures—The Red Shales—Carboniferous Limestone—The Great Conglomerate—The Coal Measures—Area of the Appalachian Coal Formations, and Thickness of their Coal and Coal Measures—Recent Coal Formations—The Jurassic Period—Richmond Coal-Field—Piedmont Coal-Field—Dan River Coal-Field—Deep River Coal-Field—Lignites, &c.

FIG. 1.

THE EARTH.

WE propose to give a brief preliminary sketch of the geology of the earth, in order to present a clear and comprehensive view of the *geology of coal* in the ascending or successive order.

The creation of the earth cannot fail to be a matter of speculation to

those who seek, in material cause and effect, its rule of existence, to whom it is not given to see the work of a divine power. But, while we ascribe the creation of the universe to the omnipotent Jehovah, let us pause for a moment to admire the infinitude of wisdom and power displayed in the governing influences which control, to our finite minds, the incomprehensible whole, and wonderingly behold the harmony of Nature's works, the uniformity of motion, the laws of gravitation, and the actions and forces of heat, and recognize in the various developments of truth, proven by constantly-recurring events, the work of a divine power replete with wisdom and love in all the structures of the universe.

CREATION OF THE EARTH.

Science informs us that our planetary system existed originally as a nebulous sphere, vaporized by heat, which appears to have been the condition of the universe under the original laws of creative force. If the ponderous or solid matter of our system was again reduced to vapor so light that it would not weigh a grain to the cubic mile, it would not fill our sphere, even within the orbit of Neptune. We know how readily all ponderous or solid bodies are reduced to vapor by heat, since water arises in steam at 212° and platina is vaporized at 2000°, while the lighter petroleums escape in the atmosphere of winter, and mercury evaporates in summer heat. But these facts are not more evident to us than the laws of condensation and gravitation. If heat vaporizes all solid bodies, cold condenses them; and we can readily conceive how a nebulous mass of vapor may contract by condensation and unite by the laws of gravitation, until masses are formed, from the size of meteors to the dimensions of worlds. Larger bodies attract smaller ones. Meteors fall towards the earth, as the earth is attracted by the sun, and only prevented from falling into it by the velocity of its motion.

To illustrate further, we may state that motion produces heat, as heat produces motion or force. The hammer striking the anvil produces heat, while rock abrading rock strikes fire. But, should our planet be suddenly arrested in its course, the shock would generate more heat than the combustion of fourteen times its bulk of coal. Assuming the mass of matter composing the earth to be equal to water in its capacities for heat, it would be fused and vaporized by 17,200 degrees, and the earth or its vapors, after being thus brought to rest, would, of course, fall into the sun, and be thus further rarefied by an additional degree of heat 400 times greater.*

In this light we can readily comprehend the natural forces or processes which tend to dissolve or unite all bodies, however large or small. It must be observed, notwithstanding the readiness of solids to escape in

* Theories of Laplace.

vapor, that no atom of matter is lost, and that none of the natural forces are wasted, since they return to the earth, or their original sphere, in equal weight or force. A common instance may be given in the combustion of coal under our steam-boilers. Here we see both water and coal consumed, and can see no return of the products of combustion: yet they return, nevertheless, in rain or gas to the earth and vegetation,—and not only return in full weight, but by their dynamic effects give a creative force, which is employed in a thousand labors by the ingenuity of man. They create a tempest of steam behind the piston of the steam-engine, equal to the force of a hundred hurricanes.

Having thus given *faint glimpses* of the natural causes controlling and governing the creation of our planetary system, since we cannot be more explicit, we may now contemplate our earth as condensed from the heated vapors of the nebulous mass, launched forth from the sun—a fiery ball—on its endless path through space.

In its swift course through space, or its orbit round the sun, our earth gradually contracted, and a primitive crust of granite encased the liquid ball, and gradually the condensation increased the thickness of the igneous or primitive rocks, as the inanimate earth, clad in dark and chaotic vapors, pursued its way. But as the crust becomes thick and cool, or no longer able to keep the surrounding vapors in a state of rarefaction, they return to the earth in the form of water or liquids; and thus we have the first day of creation, when light first illuminated the darkness.

When the vapors which shrouded the earth in endless night were condensed in rain and now enveloped it in water and steam, the second day of creation was ushered in, when God divided the waters. But from the first struggling rays of light which penetrated the vapors, until they were condensed from the "firmament" and the sun and the moon gave their light to the earth, long ages must have intervened; while nature prepared our globe by earthquake and volcano, in mountains and valleys, for the succeeding changes which took place during the third day. Then the waters rushed together in the deep places, and the elevated portions appeared as dry land, and grass and trees first made their appearance. But though mountain and sea first appeared during the third period of creation, the formation of the sedimentary rocks did not stop then. The subterranean heat was too great to admit of the existence of animal life in the water or the air; the earth still quaked and throed with internal fires, and volcanoes still vomited their lava upon the boiling waters.

During the second period, probably, the metamorphic or crystalline sedimentary strata were formed; and during the third, our palæozoic formation was deposited, its closing event being the production of the coal measures.

The "fourth day," or period, broke upon a comparatively quiet world, rich in its green freshness, and gilded by the first light of the sun and

moon that had penetrated its dark and vapory atmosphere. The cerulean blue took the place of the vapory haze, and the great lights of heaven now "ruled the day" and the night. Still the work of creation went on, and mountain succeeded mountain, here and there, where lakes and seas had existed. But the general, almost the universal, production of the stratified crust of the earth was limited even before the creation of coal, and almost suspended at the close of the fourth period.

The "fifth day" of Moses, or the fifth geological period, is marked as the dawn of the present or existing animal life: those hitherto created were low in the scale of beings, and but few were preserved through the violent changes and commotions of the primitive earth.

The sixth period witnessed the earth in the beauty and perfection of its finished state, and all animate and inanimate nature existed as it now exists, to attest the power and wisdom of the Creator.

Having thus rapidly and briefly attempted to run a parallel between our geological formations and the periods of the Mosaic creation, we shall now proceed to give a practical, though equally brief, exposition of the geological formations and periods as they exist in the lithological structure of the earth's crust.

GEOLOGICAL STRUCTURE.—PLUTONIC.

The rocks originally forming the crust of the earth, and resulting from condensation and sublimation, or comparative degrees of heat and cold, are known as *plutonic*, *granitic*, or *igneous* rocks. They form the base of all subsequent formations, and are, in fact, the primary elements from which all our lithological structure is built or derived, since even the volcanic rocks are of the same nature and origin.

We find these primary or igneous and unstratified rocks on our lowest shores and on our highest mountains, while they underlie every other formation over the entire surface of the globe, as the original crust of the earth. From its internal depths, where the creative fires ever struggled for vent, these igneous or *volcanic* rocks were poured forth in rivers of liquid *lava*, *porphyries*, *basalt*, *greenstone*, &c., and deposited through all subsequent ages and formations. Therefore the plutonic and volcanic rocks, though primarily the oldest, have become coextensive and cotemporary with every period of our geological or lithological strata. The igneous mass from which they were derived has been the means, or source, from which all or most of our metamorphic and subsequent sedimentary strata have been formed, either through the agency of volcanic eruption, which vented the molten lava into the ancient seas, or the erosion of floods and storms on the decomposing mountains, which were exposed when the waters were gathered together and the dry land appeared.

It is a question which perhaps would not be difficult of solution,

whether or not the primary elements—the vapors from which our globe was formed or condensed—contained the constituents of all subsequent productions. In fact, we cannot doubt the truth of this proposition, since it is evident we have neither lost nor gained in the quantity or constituents of the material elements forming the earth and its atmosphere since the days of creation.

The sixty-five or seventy chemical constituents of the earth or its matter, therefore, not only existed in the nebulous vapor forming the earth, but, of course, they must have existed in the plutonic rocks and the internal fiery mass of the earth, or the atmosphere surrounding it. We thus find in the bowels of the earth all the gases, the primary elements of subsequent chemical production. They formed, directly or indirectly, our *coal* and our *coal-oil*, and all the forms of vegetation and life which beautify and animate the works of Nature.

METAMORPHIC.

The second class of rocks are the *metamorphic*, exclusive of the volcanic, which are confined to no period, but are distributed through all ages and formations and are the production of all periods, even to the present. The metamorphic, gneissic, or stratified crystalline rocks repose on the granites, or plutonic rocks, which have no stratification, but are massive and devoid of all regular cleavage. But the gneiss, though approaching the granites in appearance and constituents, is irregularly stratified, and evidently a sedimentary rock, or aqueous deposit, but metamorphosed or crystallized by the action of heat; or, in other words, they were formed in boiling water, and are the results of volcanic agencies and the debris of subaqueous plutonic formations. The metamorphic rocks, however, are not all gneiss: they are widely distributed, and exist in various shapes and under various names, such as *hornblende, mica, talcose* and *clay slates, talcose* and *hornblendic gneiss, quartz, crystalline limestone, mica schist, chloritic schist*, &c. &c. These rocks exist exclusively in North America on the Atlantic slope, on the Laurentian water-shed, north of the great lakes, in the Rocky Mountains, and in the great mountain chain of California and Oregon. They contain most of our veins of gold, copper, and magnetic iron ores, and particularly the copper of Lake Superior and Tennessee and the gold-bearing veins of the Southern States and California.

In Pennsylvania, these formations have been divided by Rogers into the "ancient metamorphic" and the "semi-metamorphic," representing the *hypozoic* and *azoic* rocks, or those destitute of the ancient life or fossiliferous remains, and those (*hypo*) underlying, or beneath. The semi-metamorphic, or azoic, are at the base of the *palæozoic*, or those rocks which entomb the ancient life, and which are replete with fossiliferous remains.

PALÆOZOIC FORMATIONS.

The palæozoic strata, resting on the metamorphic, insensibly change from the semi-crystalline to the unaltered sedimentary, and are the first rocks in the order of creation which contain the fossil remains of animal life. We have, therefore, in our foregoing sketch of the Mosaic creation, made these rocks the production of the latter part of the third day, or period, in order to conform with the Mosaic account of creation. The fifth day is the period of the creation of the present or existing life, not the fossil creations of a past age. The Mosaic account only presents to the eye such prominent features or pictures of the Creation as the common mind could comprehend. (For a comparison of geology with the Mosaic or Biblical account, see Appendix.)

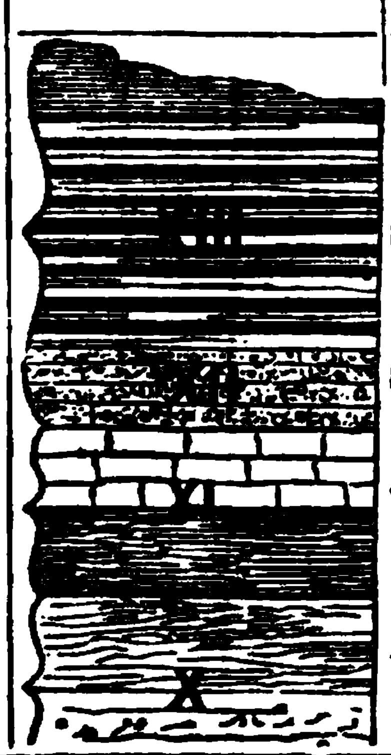
Our palæozoic strata embrace the *Cambrian*, *Silurian*, *Devonian*, and *Carboniferous* formations of the English geologists, and occupy one-half the area of the United States, or nine-tenths of the State of Pennsylvania, where they range from 10,000 to 35,000 feet in thickness.

The accompanying column or vertical section of the palæozoic strata of Pennsylvania presents a comprehensive view of the entire formation, from the gneissic to the carboniferous, including the coal measures.

We have divided the column, according to the nomenclature of Rogers, into fifteen periods, or formations, and numbered them in the mode adopted by the early surveyors of the State. We have also given the names adopted by the geologists of New York and the English equivalents, in order to present practically to the eye and the mind of all classes of readers the names and positions of the rocks forming the palæozoic strata of Pennsylvania. The many new names adopted by the geologists of different sections for the various strata tend to confuse the mind; but we hope our present exposition will present them clearly.

PALÆOZOIC COLUMN.

FIG. 2.



FEET.	PENNSYLVANIA.	NEW YORK.		ENGLISH.
500 to 3000	Seral Coal Measures.	Absent in New York.	Carboniferous.	Coal Measures.
10 to 1000	Seral, Conglomerate.	Absent in New York.		Millstone Grit.
0 to 2000	Umbral, Red Shales.	Carboniferous Limestone.		Carb. Limestone.
200 to 2000	Vespertine, White Sandstones.	Gray and Yellow Sandstone.		Subcarboniferous.

Feet.	...ania.	New York.		English
0 to 5000	...ndstone.	Catskill.	Devonian.	Old Red Sandstone.
1700 to 5000	...les and	Chemung Group. Portage Group.		Eifel.
1500 to 2000	...k Slates,	Genesee Slate. Hamilton Slate. Marcellus Slate.		Eifel.
	.	Corniferous Lime. Onondaga Lime. Schoharie Grit, &c.		
600 to 1500	...tone. ...mestone.	Oriskany Sandstone. Lower Helderberg.		Ludlow.
1000 to 2000		Saliferous. Niagara.	Upper Silurian.	Wenlock.
1000 to 2000	Shales.	Clinton Group.		Wenlock.
250 to 2500	... Sand-	Medina Sandstone. Oneida Conglomerate.		Caradoc.
500 to 2500	...nd Lime-	Hudson River Slates. [illegible] [illegible] Limestones	Lower Silurian, or Cambrian.	Bala Rocks.
1400 to 6000	...stones.	Trenton Limestones, &c. Chazy Limestones.		Festiniog Group.
1000 to 4000	...ne.	Calciferous Sandstone. Potsdam Sandstone.		Lingula Flags.
5000 to 30,000		Gneiss.		

THE PRIMAL STRATA.

The lowest series of rocks in the palæozoic column is the Primal, or Potsdam sandstone, which covers an area almost coextensive with the gneiss upon which it rests, and is found from the British provinces on the north to the middle of Alabama in the south, and from the Blue Ridge on the east to the Rocky Mountains and the mountains of California to the west.

It is the distinguishing feature of the Blue Ridge on its western slope, and notes the continuation of this range into Pennsylvania, as the Reading and Easton hills.

AURORAL AND MATINAL STRATA.

The second and third series are the Auroral and Matinal limestones and slates. They are of immense thickness, and cover a vast area of territory. This formation seems to have formed the bed of the ancient Appalachian sea, and is traceable, by its outcrops, from the valley of the St. Lawrence, until it is lost beneath the alluvial of the Gulf, but reappears in the West, and spreads out widely in Missouri, and on the anticlinals of the Western coal-fields.

Those limestones and slates form one of the most magnificent valleys in the world, along the Atlantic slope,—scarcely second to the valley of the Mississippi, if we consider the productiveness of its soils, the richness and variety of its minerals, and their general availability. This great region extends from Canada through New York into Pennsylvania, Maryland, Virginia, Tennessee, Georgia, and Alabama.

It is locally known by various names: as, the Newburg Valley, the Lehigh Valley, by Easton and Allentown, the Reading and Lebanon Valleys, the Cumberland Valley, the Great Valley of Virginia, the Valleys of East Tennessee, and the beautiful valley of the Coosa in Georgia and Alabama, embracing a length of about 1500 miles, and an average width of 20 miles, covering an area of 30,000 square miles.

Close to its eastern borders, over the Blue Ridge, lie the great region of magnetic ores,—from the Adirondack hills to the Carolinas; while parallel run the copper belts of the gneissic and primal formations. It is the great region of hematitic ores, which are largely developed from Pennsylvania to Alabama.

These ores are generally the rich brown, or hydro-peroxide,—except in a few localities, as at the great magnetic deposits of Cornwall, Pennsylvania. They not only produce the best of iron, but are invaluable as a mixture into the refractory magnetics. The extent and profusion of these beds of ore, which extend in almost unbroken veins from end to end of this great limestone valley, cannot be realized by persons who have not

witnessed the facts. We have seen masses of this brown ore, that may be literally termed mountains, in Virginia, Tennessee, and Alabama. It is as inexhaustible as the great coal-fields which lie along its western border, and which are almost everywhere accessible, and at some points quite near, —the Lehigh coal at Allentown, the Schuylkill at Reading, the Swatara at Lebanon, the Shamokin, Wyoming, and Broad Top at Harrisburg, the Cumberland at Harper's Ferry, the Kanawha and New River coals at "Central" on the New River, the Chattanooga coals at Cleveland and Dalton, and the Coosa coals in Alabama.

This great valley is drained by the waters of the Atlantic, as far south as middle Virginia, and is everywhere accessible by river and rail from the seaboard cities. The Hudson, Delaware, Lehigh, Schuylkill, Susquehanna, Potomac, James, and Roanoke Rivers drain it from the east through the passes of the Blue Ridge; while the New River, the Holston or Tennessee, and the Coosa drain it from the west and south.

The hard and flinty rocks of the Primal series, including the great *Potsdam sand-rock,* forms the eastern confines of the valley, in a continuous and almost unbroken line, from the Lehigh to the Chattahoochee,—a vast mountain chain that alternately rises or sinks as its strata assume a high or low degree of angle, but always a mountain, and sometimes stupendous in its grandeur.

LEVANT, SURGENT, SCALENT, ETC.

The immediate western boundary of this limestone valley are the rocks of the succeeding or Levant series, but principally the great *Medina sand-rock,* that rises in vast proportions in the mountain chain that forms its western edge. It rises thin and low in Northern New York, but thickens as it sweeps around the Catskill, and rises grandly as the Shawangunk of New Jersey, the Blue Mountains and Kittatinny of Pennsylvania, and the North Mountain of Virginia. It continues its course south parallel with the valley, high and unbroken, towering steeply from 1500 to 2000 feet over its western edge, a vast mass of rock, often 2000 feet thick. It is locally known as the Walker and Clinch Mountains of Northwestern Virginia and Tennessee, and the Lookout Mountain of Georgia and Alabama.

But this great Levant or Medina sand-rock, and its accompanying strata, is not merely confined to this single parallel range; it undulates westward, and rises, in high anticlinals, wave after wave, until lost beneath the coal-fields of the West, where it thins to insignificant proportions.

SURGENT SHALES, ETC.

Overlying the Levant sand-rock are the *Surgent shales,* made up of red calcareous marls, fossiliferous limestones, and calcareous sandstones, con-

taining several beds of rich fossiliferous iron ore, which is found from New York to Alabama, but has its maximum thickness or value on the Coosa in Alabama.

Following the *Surgent*, in ascending order, we find the *Scalent* and *Meridians* of Rogers, comprising numerous beds of gypseous marls, limestones, shales, and thin sandstones, and which form the valleys that follow the undulations of the great Levant rocks. But though these valleys run a subordinate range of hills, formed by the outcrops of the Oriskany sand-rock, or No. VII,—a coarse, calcareous rock, almost a limestone in its lower beds, but a hard, iron-stained chert where elevated or exposed to the atmosphere. It forms the celebrated Pulpit Rocks of the Juniata.

CADENT, VERGENT, AND PONENT.

The Oriskany sand-rock appears to represent a place in the Ludlow rocks of England, and the base of the Devonian period of the English geologist. It forms a break in the Palæozoic strata, and forms a change of the ancient life: a new creation begins here.

The Cadent series are made up principally of slates, shales, and limestones, generally highly bituminous, and range from the Corniferous limestone to the Genesee slates of New York. These formations may be considered as the lower *oil-producing rocks*, commencing with the corniferous lime, which is saturated with *oil*, wherever found, in New York, Pennsylvania, or Illinois. The following, or Vergent series, comprising the Portage and Chemung groups of New York, are also bituminous in character, and made up of vast beds of gray, blue, and olive-colored shales, and gray and brown sandstones, in thin layers or flags, parted by bands of soft blue slate, and abounding in fossils of fucoids or sea-weeds.

The Ponent rocks are thick masses of red shales and red and gray sandstones, and are represented by the Catskill of New York and the *Old Red Sandstone* of the English.

All these formations have their maximum thickness along the Atlantic slopes, or the eastern borders of the great Appalachian chain or basin, and they all thin rapidly as they extend westward, with the exception of the limestones, which appear to increase in thickness as they approach the interior of the ancient sea. It is probable, however, that the rocks forming its eastern boundary will also be found to predominate along its western margin and on the eastern slope of the Black Hills and the Rocky Mountains. (?) The old red sandstone is lost in the western basins.

VESPERTINE.

This formation is the lower base of the coal measures. It is the subcarboniferous of the English, and contains the *proto-carboniferous* or *false* coal

measures. Its features are bold, characteristic, and prominent, and present much uniformity around the Anthracite Coal-Basin, the detached portions of the Alleghany coal-field, and along its eastern escarpment.

The *vespertine white sandstone* is of great thickness. Its Atlantic outcrop is two thousand feet thick, while the supporting "old red" or ponent is nearly a mile in thickness. These immense masses of rocks rise like a framework of mountains around our coal-fields, following them in parallel belts of *red* and *white* with artistic and picturesque effect.

Prof. J. P. Lesley, in his little, but valuable and interesting, "Manual of Coal," from which we have borrowed many useful facts, thus speaks of those red and white sandstones as the floor or base of our coal-fields:—

"The THIRD GREAT SANDSTONE of the floor, No. X., is not so remarkable for introducing a new era of fossil life, as for inaugurating a new system of groups of mountains along its frequent outcropping, which keeps them always and everywhere apart from the groups of No. IV. (Levant), never approaching them within three miles, and usually running in parallel lines with them at a variable distance of from ten to twenty miles, the intervals being always filled up with the narrow knobs of the Oriskany, No. VII., and the broad, high, undulating, deeply-ravined, and always cultivated hills of No. VIII.

"On the out or lower side of all these mountains of X., runs an uneven terrace of the red sand of IX.; and in those regions where the rocks stand vertical, this terrace rises to a separate summit of equal height with the true summit, and beautifully parallel with it; a narrow, shallow crease divides the double summit, and then the long, straight mountains, with twin crests of wonderful evenness, but with this difference, that the outside one is red and the inside one is white, runs along the map like the double beading of a picture-frame. This is true of all that southeastern outcrop which encircles the Anthracite Coal-Basins, folding scrupulously in and out around their long sharp points, crossing and recrossing the rivers and creeks, and presenting always outwardly, or *from* the coal, its terrace of old red sandstone. The same red and white frame is repeated around the Broad Top Coal-Basin, south of the Juniata.

"The Terrace Mountain is its northern point and western side, and Sidelong Hill is its eastern. The same surrounds the Cumberland Coal Region. This is the formation which constitutes so many of the long, straight parallel ridges of Central and Southwestern Virginia. Like the Medina sandstone last described, it is of immense thickness in the east and thins rapidly towards the west. Its Atlantic outcrop is over two thousand feet thick, hard and white, while its supporting red rocks, No. IX., are at least a mile in thickness. Only the upper part of this red mass, however, forms the terrace or supplementary crest, except when they all lie nearly horizontal. This is the case with the Catskill. Here the

vast piles ascend in steps a height of three thousand feet, IX. upon VIII. and X. upon IX., and on top of all the lower layers of XI. But as we follow this easternmost outcrop south through Virginia into Tennessee, it slowly thins, as if the original direction of the sediment was from the north and east. Yet more striking is the case when we pass over to its inner outcrops. Around the Broad Top, and where it passes down beneath the Great Savage, it is still a mountain mass, but it rises again in Ohio and Northern Pennsylvania from its underground journey so lean and changed as scarcely to be recognized. It is there a greenish sandstone less than two hundred feet thick. The whole intermediate space, of course, it underlies; that is, all Northern and Western Pennsylvania, all Western Virginia, and the whole southern region of the Cumberland Mountain. Here it is as thin as in the Catskill region, but here, as there, helps to pile up the immense plateau which, narrowing as we go southward, domineers with its lofty terminal crags the plains of Alabama."

THE FALSE COAL MEASURES.

The false or proto-carboniferous formation overlie the vespertine rocks. This formation is, perhaps, cotemporary or of the same era with the English lower coal series, beneath the millstone grit. It rarely develops in any commercial value in our American formations, but is coextensive with the Appalachian Coal-Basin. We find thin traces of coal and coal-slates beneath the red shale or on the vespertine, around the anthracite formations, and everywhere along its inside or upper face from the Catskill to the Lookout, and at the base of the eastern escarpment of the Alleghany Mountains thin seams of this coal have been found, and many have picked and pried into them without profit, except in practical experience. Those false coal measures, and the thin, imperfect coals they bear, have been opened or proved near Altoona, on the Pennsylvania Railroad, at the base of Sidelong Hill, Berkeley county, on the north branch of the Shenandoah, in Augusta county, and on the New River, in Montgomery county, Virginia, and in other localities further south. But the coals of this system have never been developed in workable quantities or of marketable value, except on the New River, in Virginia; and here we find a truly valuable deposit of workable and marketable coal. But even here there is no uniformity of strata, and mining operations are subject to numerous interruptions from "up-throws" and "down-throws," and frequent faults of *slate* and *dirt*, which mar the coal. Yet this is a valuable deposit, nevertheless, and deserves an extended notice in connection with the coal-fields of Virginia and the South, and which will be found further on in its appropriate place, from our own practical experience.

UMBRAL RED SHALES.

We have now reached the red shales of our coal-fields, so well known, and so easily distinguished by their peculiar color and thin, soft, and generally friable nature. This must have been a pure red mud, as it now forms the softest of rocks, and could only have been the shore deposits of a quiet sea.

This soft red shale of No. XI. encircles our coal-fields between the vespertine, No. X., and the next overlying or great conglomerate, No. XII. of the true coal measures. It is generally cut down by the stream in low, deep valleys, with the vespertine white rocks towering in mountain form on one side, and the great conglomerate in almost equal bulk on the other. Occasionally these red shale valleys are widened out by the undulation of the strata, and present fertile and cultivated valleys amid the wild and barren mountains of X. and XII. We may note, for instance, the Quakake, Nescopeck, Catawissa, Mahantango, and Lykins valleys, as surrounding the anthracite coal-fields; while others of more or less note exist around the Alleghany spurs and the detached coal-basins on the waters of the Susquehanna.

This deposit thins rapidly in a western direction. Though it is 3000 feet thick on the Schuylkill and Lehigh, south of the anthracite fields, and 1000 at Broad Top and on the New River, in Southwestern Virginia, it is only 200 feet thick in the eastern escarpment of the Alleghany, along the head-waters of the Juniata, and is lost to view before it reaches the Alleghany and Monongahela Rivers.

This disappearance is owing more to a metamorphism than a depreciation. We lose sight of the red shale, but it is simply a change from the red mud of the eastern shore of the Appalachian Sea to the mountains or great carboniferous limestone of its interior basins. The limestone predominates and increases invariably towards the centre of the Appalachian formations; while the sandstones, shales, slates, and coarse conglomerates of its eastern margin depreciate in the same direction, and all those formations become finer in grain as they become changed in bulk and character. This Umbral limestone, which usurps the place of the Umbral shale, is very thin on its northeastern edges; commencing in the middle of the red shales but a few feet thick, it increases in thickness in a southwestern direction as rapidly as the red shale diminishes. But this great carboniferous limestone—identical, undoubtedly, with the British carboniferous lime—does not appear to diminish in the same proportion towards the western margin of the ancient or Appalachian Sea. It is found in the Black Hills and the Rocky Mountains, and even farther west, to the plateaus of Sonora and the Sierra Nevada, of California, giving positive evidence of the existence of coal in those great western unexplored regions.

THE GREAT CONGLOMERATE.

This is the fourth great sand-rock in the palæozoic formations, and is the immediate floor or base of the true coal measures. It is deposited on the mud of the umbral red shales in the east, where it is of great thickness, and is composed generally of a conglomeration of pure white water-worn quartz pebbles, from the size of a pin-head to that of a pigeon's egg, cemented together by natural processes.

This rock is 1000 feet thick on the eastern and southern edges of the anthracite coal-fields, but gradually thins in a northwestern direction to a mere plate of coarse-grained sandstone,—occasionally presenting conglomerate pebbles,—from ten to thirty feet in thickness, and extending from Pennsylvania to Alabama, Missouri, and beyond.

This great bed-rock of the coal-fields is, to a certain extent, indestructible. It hardens in the atmosphere, and yields not to the action of water. There are but few rocks which are harder and more tenacious, or which have yielded less to the abrasion of the denuding forces. We quote still further from Prof. Lesley's manual:—

"This much, however is certain, and should excite our admiration as one of those curious coincidences which may well bear the name of Providence, and be received as evidences of the forethought of benevolence, that we are indebted to this enormous local eastward thickening of the conglomerate proper and the conglomerates sandstone above it, for our anthracite treasures.

"Had the rocks beneath the anthracite coal been the mere thin sheets of sand which they are westward, weakened still further by intercalations of clay and coal, their outcrop edges never could have withstood the rush of denuding waters, and protected as they did the mineral fuel within their gigantic folds. What now are groups of long, slender, united, or closely-parallel coal-basins, would have been, but for this protection, wastes of red sandstone, or deep lakes in the olive shales of No. VIII., like those of the north. The comparatively little coal that has been hardly left in these small basins would have gone the way of all that vast original deposit the debris of which lies buried under the profoundest bottoms of the Atlantic, together with the immensely greater ruin of the formations underlying and preceding it."

THE COAL MEASURES.

In this outline sketch we wish to present clearly and in a practical manner, not only the place of *Coal among the rocks,* but to illustrate briefly the extent of our great Appalachian formations, or the immense area of the American coal-fields within its wide embrace, which reaches from the

Laurentian basins to the cane-brakes of Alabama, and from the anthracite fields of Pennsylvania to the uncertain deposits of the Black Hills on the eastern slope of the Rocky Mountains.

The greatest development of the coal measures or the coal which they contain is on its eastern borders, in the anthracite basins of Pennsylvania, and the great Alleghany coal-field, which occupies so large a part of its vast area; and this seems to be in conformity with the subordinate stratas, which also have their greatest development along their Atlantic margin. The average vertical thickness of the workable Pennsylvania anthracites being sixty feet, while its total or maximum thickness will reach over a hundred feet; the workable coals of the Cumberland basins, in Maryland, is thirty-five feet, while the maximum is about fifty feet. The average workable thickness of the Alleghany coal-field is twenty-five feet, while its maximum is fifty feet. The average workable thickness of most of the developed Western fields is ten feet, while the maximum may be computed at twenty-five feet; and thus we find a gradual thinning, of not only the subordinate strata, but also the overlying coals which they support, from the east to the west. But we may here state the fact, our extreme western margin of this great coal area is to the present generation a *terra incognita* as far as its geology and minerals are concerned, and we cannot say to what extent the common depreciation has been carried beyond the central basins.

THICKNESS AND AREA OF THE APPALACHIAN COAL FORMATIONS.

In this estimate of the Appalachian coal areas, we are guided by Prof. Rogers, who has furnished the latest available information on the subject.

"The eastern half of the continent contains five great coal-fields, distributed at intervals from Newfoundland to Arkansas.

"The first, or most easterly, is that of the East British provinces,—Newfoundland, Nova Scotia, Cape Breton, and New Brunswick,—originally a wide coal-field, broken into patches by uplifts of the older strata and by the waters of the St. Lawrence Gulf. The surface covered by the coal measures of the provinces is probably about 9000 square miles, but apparently only one-tenth of this area is productive in coal.

"The second, which I have called elsewhere the great Appalachian coal-field, commences in Pennsylvania and extends southwest to near Tuscaloosa, in Alabama. This includes several outlying lesser basins,—those, for example, of the anthracite coal in Eastern Pennsylvania. It has a total area of 70,000 square miles.

"The third is the smaller coal-field of the centre of Michigan, equidistant from Lake Huron and Lake Michigan. The area of this may be given at about 15,000 square miles. It is deficient in coal.

"The fourth is the great coal-field lying between the Ohio and Mississippi anticlinals, and spreading in the form of a wide elliptical flat basin from Kentucky north through Indiana and Illinois to Rock River. This possesses an estimated area of 50,000 square miles.

"The fifth and most west is a long and large coal-field, occupying the centre of the great basin of carboniferous rocks which spreads from the Mississippi and Ozark anticlinals west to the visible limits of the palæozoic region, where it is overlapped by the Middle Secondary and Cretaceous deposits of the prairies. The northern limit of this coal-field is in Iowa, on the Iowa River; the southern is near the Red River on the western confines of Arkansas; and the total area of the great irregular basin is not less than 57,000 square miles.

"Summing up the several areas here defined, we perceive that the broad coal-fields of North America occupy the enormous space of at least 200,000 square miles, or more than twenty times as large a surface as that which includes all the known coal deposits of Europe, or probably of the Eastern Continent.

THICKNESS.

"Comparative measurements of the thickness of these several deposits of the American coal-fields, indicate a marked reduction from the east towards the west. Those of the Nova Scotia field, as measured at the South Joggins, Bay of Fundy, show a thickness of nearly 3000 feet; those of the southeastern anthracite basin of Pennsylvania, an average thickness about as great; while the central portion of the great Appalachian bituminous basin has a depth not exceeding 2500 feet. Those again of the Illinois basin are probably not thicker than 1500 feet; while the last, the Iowa and Missouri basin, is evidently much shallower, its total depth not surpassing probably 1000 feet.

"In Nova Scotia, the coal-fields contain, in the Joggins section, in all about fifty seams of coal, only five of which, however, are of workable dimensions. These are equivalent to about twenty feet of coal. In the deepest anthracite basin of Pennsylvania, that of Schuylkill, there are, where the formation is thickest, about fifty seams in all; but twenty-five of these have a diameter exceeding three feet and are available for mining. In the great Appalachian coal-field there appear to be twenty beds in all, and nine or ten of these are of workable size. Again, in the broad basin of Illinois, Indiana, and Kentucky, the total number amounts to eighteen; and it is believed that seventeen of these are of a size and quality suitable for mining. Only two or three such are believed to exist in the shallow and much denuded basin of Michigan.

"Still further west, the coal-fields of Iowa and Missouri contain, it is believed, only two or three beds thick enough to be profitable, while the

total number of seams of all sizes is probably not more than twelve or thirteen."*

RECENT COAL FORMATIONS.

We cannot properly close this geological sketch of the rocks of the earth and the place of coal among them, without referring to the coal formations of a later date than our true carboniferous coal measures. Of those later formations we have several deposits in Virginia and North Carolina.

The palæozoic strata of this continent are rarely overlaid by the more recent formations, except in the western and less explored portions; while in England we find the new red sandstone and magnesian limestone immediately overlaying the coal. It has been reported that we have a small coal formation known as the Permian,—which belongs geologically immediately above the true coal measures,—over the coal of one or two of our western fields. Most of our new or late deposits lie along the ocean belts and amid the oldest rocks of the earth. Thus, for instance, we find the *Jurassic* coals of Virginia and North Carolina deposited in or on the granite and gneiss rocks of those States.

FIG. 8.

RECENT FORMATIONS.

The Jurassic is of later date than the Permian and *Triassic*, and nearly cotemporary with the Oolitic.

In order to embrace a full stratigraphical view of American geology, we give an illustration of the formations following the palæozoic in order. This column, it will be observed, rests on the granite,—an unusual and perhaps anomalous position,—but nevertheless represents the true status of those formations. The Jurassic contains the coal of Richmond and Deep River, while the formations resting in the order of their age above it, are all

* The reader is referred to Chapter XIX. We have found it necessary to change these figures.

deposits of a late period, and, in this county, are generally found resting on the older rocks which now bound these ocean shores.

We will merely notice those Jurassic or recent coal-fields in the present connection, reserving an extended description for its appropriate place in the ensuing pages.

The RICHMOND COAL-FIELD lies on or in a deep—perhaps volcanic—depression in the granite. It is about thirty miles long by five miles wide, and contains one hundred and eighty square miles of coal formation. The depth of the basin is about one thousand feet; the average thickness of its coal is about twenty-four feet. It is highly bituminous and gaseous, disintegrates readily in the atmosphere, and is liable to spontaneous combustion.

The PIEDMONT COAL-FIELD is on the Appomattox, in Prince Edward and Cumberland counties, Virginia, ranging in a northeast and southwest direction from the Roanoke to the James. The formation rests on the gneiss, and is frequently cut and interrupted by trap dikes. The coal-bearing strata are, perhaps, not more than twenty miles long by three miles wide, containing an area of less than twenty square miles of coal. It contains seven or eight seams, ranging from six inches to three feet in thickness, and not more than nine feet of workable coal, of a sulphurous and earthy nature.

The DAN RIVER COAL-FIELD has yet no fixed location or name. It extends from Leakesville to Germantown, a distance of thirty miles, in the same general northeast and southwest direction. The formation is in the vicinity of the gneiss, but is, we believe, underlaid by sandstones and slates. The coal is semi-bituminous, and contains specimens similar to the Pennsylvania anthracites. The seams are limited and small. We take this to be a continuation of the Piedmont basin.

The DEEP RIVER COAL-FIELD of North Carolina rests unconformably upon the mica slates of the gneissic period, and the material making up the formations is chiefly derived from the gold belt in the immediate vicinity. The area underlaid with coal is about forty-five square miles. Five seams of coal exist, the main one being from five to six feet thick.

We may merely mention here the existence of other mineral combustibles, such as lignite, &c., which are found in still more recent formations; but, as we do not propose to devote much time or space to their consideration, it is not advisable to extend this geological sketch for the purpose.

CHAPTER III.

FORMATION AND ORIGIN OF THE APPALACHIANS.

The Appalachian Basin—Ancient Appalachian Sea—Eastern Volcanic Coast Range—Depth of the Sea—Ancient and Modern Formations—Depression of the Crust—Lateral Contraction—The Great Limestone Bed of the Sea—Its Immense Store of Carbon—Carbonic Acid and Hydro-Carbon—Red Shales—Conglomerates—Coal Measures of the Ancient Basin—Ancient Rivers—Drainage of the Continent—Physical Changes—Condensation—Vacuum—Inverted Strata—Deep Basins.

THE COAL VEGETATION COMMENCED.

In the present chapter or stage of our work it seems essential that we should present a concise view of the probable erection of the Appalachian mountain-chain, and the great basin which by common consent appears to bear their name, in all descriptions of that ancient sea which formerly occupied the eastern half of our continent, and which is now occupied by those great ranges of mountain and valley from the Blue Ridge to the Rocky Mountains.

So little is known, practically, of this the greatest mass of the earth's physical proportions, that we propose to state simply such facts as are well attested, or self-evident, in relation to its ancient bed, the origin of the strata which now occupy its deep recesses, and the natural processes which occasioned the change. We propose to separate fact from theory as far as possible; but our conclusions must occasionally be theoretical. Yet, as a preliminary introduction to the *origin and formation of our coal-fields* resting in and on those Appalachian basins, it seems peculiarly appropriate that we should first consider the origin and nature of the older and supporting formations; since it will appear evident, as we proceed, that the production of the first was, to a great extent, necessary to the formation of the second.

THE ANCIENT APPALACHIAN SEA.

The margin of this ancient sea is not only now plainly defined to the eye of the geologist, but an investigation of the fact would lead to the same result.

In the first place, we do not merely infer, but we know, that originally the highest portions of the earth were mountains of the *plutonic* rocks, granite, &c., and that the boundaries of the ancient seas must have been those walls of granite,—since the gneiss, or first sedimentary rocks, could not exist until those mountain-barriers were erected to confine the

ancient waters, in which only the crystalline or stratified gneiss could be formed. It is thus evident that the great zone of granite and gneiss which extends from Newfoundland, or Nova Scotia, in the northeast, to the end of the great Appalachian chain in Georgia, or perhaps to Cuba and beyond; and from the same point, north of the St. Lawrence and the great lakes, must have been the northeastern and southeastern boundary of the ancient sea. That this great zone or belt of granite was originally an elevated mountain-range, cannot be doubted, since it is positive that the waters which it confined were once as high as the tops of the Alleghanies. We are not left, however, to bare statements of this fact, since part of this great and ancient mountain-range still exists, with, perhaps, much of its olden grandeur.

We may merely mention the granite hills of New Hampshire and Maine, before we offer in evidence the vast and stupendous granite mountains which pile up, in successive ranges, along the eastern margin of the Appalachian basin, in Southwestern Virginia, Northwestern North Carolina, East Tennessee, and North Georgia. Here, where the denuding agencies of the escaping waters had no effect, the eastern barriers of the ancient sea still exist; and, had not the destructive effects of fire and water operated more violently in the northeast than the southeast, we should still find those impassable mountains barring our way to the West and cutting us off from the coal of the inland valleys: in fact, we should have mountains where we now have plains, and barren hills of granite where our cities now stand.

In order to strengthen the evidence still more, we may cite the fact that along this entire line or belt of granite unmistakable evidence is found of its early volcanic nature. Deep dykes, as the last effects of expiring volcanoes, are found from Nova Scotia to Georgia,—generally along the eastern margin of the gneiss, but frequently through it.

The facts here stated must be borne in mind, to properly appreciate the facts which are to follow. Having given the bounds of the ancient sea, we may now state its depth; and here we are not left to mere conjecture, for the *thickness* of the Palæozoic strata which now fill its bed is evidently the measure of its depth.

The sum of their thickness has been measured pretty accurately by the geologists of the State. It ranges in the east from 25,000 to 35,000 feet, or from 5 to 7 miles, in thickness! Now, when we consider that the Palæozoic formations are only part of the sedimentary rocks, which fill the deep caves of the ancient sea, that the metamorphic or crystalline sedimentary strata still underlies, perhaps to the depth of 10,000 feet, or two miles more, and that the present elevation of the remaining portions of the ancient mountain-barrier in Virginia and Pennsylvania is elevated at least five thousand (5000) feet above the sea,—a base-line we have adopted,—

we can form some conception of the enormous depth of the great sea to the east. This computation would give a depth of *ten miles*. But there are modifications of this estimate, such as the subsequent depression of the strata, which perhaps may have reduced the depth to two-thirds or one-half the above vertical line. Yet the fact of an enormous depth still exists, even in five miles of water!

From the fact of depth, which cannot be doubted, we must assume another fact, which is no less self-evident,—which is, that the mountain-barrier, or line of granite, bounding this deep sea, must have had one deep, perpendicular, or weak side, adjoining the waters on the west; while that on the Atlantic, or east side, must have existed to some extent in its present gradually inclining form, since there is no evidence of change. The granite still exists, though greatly depressed.

We see now before us a long line of high and steep granite shores, and a deep, unfathomable sea; and we have the existing evidences that these mountains were actively volcanic even until a late day, when the ancient sea no longer existed. The consequence has been that both the ancient mountains and the sea have disappeared; the mountains displaced the sea, but the sea swallowed the mountains.

Here we may introduce an illustration of the rocks which fill the basin, and the natural causes which led to this result. It will aid in exemplifying the hypothesis we set forth, and which we hope to prove more by facts than by mere scientific conclusions, which hitherto have been our rule in fathoming what seems a natural phenomenon.

APPALACHIAN FORMATIONS.

In the accompanying illustration, Fig. 4, we do not give the details of the foldings and steep reversed dips of the mountain-chains now filling the eastern edge of the ancient sea. Such detail would not affect the question, but would, in the limited space to which we are confined, complicate and confuse the general idea we wish to impress.

It will be noticed that on the left, or east, the granite rocks still form, on a lower line, the bounds of the basin; while in the background, on a higher line, is shown the ancient volcanic belt towering above the Alleghany summit; while the streams of lava from its crest are poured into the great sea, forming, in the early periods and in the boiling waters, the crystalline gneiss, and during later eras, the higher sedimentary sand-rocks.

It will be proper to remark, here, that the line represented by the illustration is a transverse section across the Appalachian chain by Cumberland, Maryland, and does not fairly present the deep flexures of the east or in the vicinity of the anthracite coal-fields, whose location are, however, denoted.

FIG. 4.

APPALACHIAN FORMATIONS, MODERN AND ANCIENT.

DESCRIPTION OF ILLUSTRATION. *Modern.*—*a*, the Atlantic sea; *b*, recent, or cretaceous formations; *c*, granitic and volcanic; *d*, Mesozoic, new red, etc.; *e*, metamorphic, gneissic, etc.; *g*, sandstones and limestones of the valley, or the lower palæozoic formations; *h*, slates and shales of the oil-producing formations; *i*, sandstones overlying the oil strata, including the *old red*, and the conglomerate; *j*, the anthracite coal deposits; *k*, Cumberland coal-field; *l*, *l*, *n*, Alleghany coal-field; *m*, Ohio River.

The Potsdam sandstone underlays the Auroral limestone, *g*, and overlays the gneiss, *e*, which must exist to some extent in the entire basin. The dark vertical trap formations emerge from the granite, and were the means of forming the gneiss.

Ancient.—No. 1 corresponds to *a*, and is the granite sea-coast line, forming the volcanic boundary of the ancient sea; 2 is a deep view of the volcanic vent between the granite and the gneiss, which is formed of the vented matter; 3 is the metamorphic, or early gneissic, sedimentary rocks; 4 corresponds to *g*, and is the base of the palæozoic; 5 are the bituminous slates of the oil strata, followed by the massive sandstones of the *old red*, and the subcarboniferous; 6 is the ancient sea, since filled by the sedimentary deposits represented in *g*, *h*, *i*, *j*, *k*, *l*, &c.; 7, 7, is the line of volcanic vents existing in the plutonic, or granite coast-line, which extends from Maine to Cuba. The form of the ancient structure is, of course, ideal, and the two views are thus given together in order to convey an impression of the *cause* and its effects.

The delineation of the topographical features and the precise undulations of the strata is not attempted in the *modern* structure, since we could not portray them on so small a scale and preserve a general and comprehensive view of the order of the superstructure.

It will, of course, be noticed that the illustration represents two distinct pictures. The foreground, *lettered*, should be entirely removed from the *figured* background, in order to present each distinctly; but as the latter disappears, the former takes its place. The modern is the result of the ancient.

It is also necessary to remark that volcanic action was not confined entirely, though principally, to the surrounding granite zone. In all probability, active volcanoes existed in the interior of the basin, particularly before the formation of the *great limestone*,—the Auroral, or No. II., of Rogers,—as we have shown in several instances; but their location we can only tell by the anticlinals which now swell the surface. And these are not positive evidences, since the original surface of the granite floor was, in all probability, usually corrugated and uneven. Those minor details, however, do not affect the proposition regarding the origin and formation of the great basin, which we assume to be as generally set forth: that the ancient sea was deepest on the northeast, and bounded by a zone or belt of volcanic mountains, which produced the material, in part or in whole, now reposing in its deep gulfs.

As before stated, the granite shores were precipitous, and, consequently, weakest on the east or sea margin. Hence, volcanic action was confined to that side, and the mountain-barrier gradually worn down as the waters became shallow by the filling up of their depth. The enormous amount of material thrown into those deep basins would naturally raise even the waters of the sea, and as naturally cause not only the general depression of the crust of the earth in an eastern direction, but wear down the mountains themselves. The most natural consequence of this raising of the waters and depression of the land which confined them, was the final escape of the pent-up sea from its ancient limits, and the overflowing of the land to the east; and whether the Atlantic then existed on a level with the Appalachian Sea or not, the effect would be the same; for the granite hills of the east, worn on one side by the billows of the Atlantic, and on the other by the waves of the ancient sea, could not resist their abrading influences, while the fierce volcanic action still wore down the crater and still depressed the crust.

But a portion of the ancient barrier resisted the combined attacks, and still stands to attest the magnitude and grandeur of those ancient limits. We allude to the mountains of East Tennessee and the adjoining States. Yet it is singular that the thickest portions of the crust, or where we might assume the greatest magnitude of mountain border to have existed, towards the northeast, first yielded to the combined action of the fire and water. It is, however, only another fact to prove the general truth of the hypothesis, since the investigations of all our geologists show that the greatest amount of solid matter now filling the great basin came from a northeastern direction; and hence the more rapid subsidence of the crust in that locality, since such would be the natural sequence of the more rapid ejection of the fluid matter supporting the crust.

We may here observe, this violent change of subterranean matter from the interior to the exterior of the earth not only lowered the crust of the

earth in one direction and raised it in another, but had the effect of flexing and frequently inverting the strata which had been formed in the vicinity of the deeper basins, and within the influence of the contraction, caused by the spasmodic action of the internal volcanic heat; that is, the strata deposited on the sharp axes of deep synclinals, or basins, would be further deepened by the contraction or subsidence of those basins; while the surface would rather contract, also, than expand under the same influence, and thus the angle of the strata become greater, and, in many cases, even inverted. But this we do not assume to be the only cause of the inverted strata, so prevalent in the East; though we think it the chief or normal cause.

The sedimentary strata would naturally conform to the surface over which they were stratified; and as the granite surface is, and apparently was, generally uneven, the metamorphic or gneissic strata first deposited assumed the corrugations and angles of the original foundation. These appear to have been in long lines running northeast and southwest, wide and broad in the west and centre of the great basin, and narrow, steep, and deep towards the east. On those the Appalachian chains were folded, growing narrower and steeper as the basins subsided, with the general crust movement towards the east; and, as the crusts of the strata came closer together, by the general or lateral contraction.

It is very evident that our sedimentary strata were not laid horizontally when originally deposited, but conformed, as we have stated, to the general uneven surface of a granitic and volcanic period; yet many of our geologists assume such to be the general law, and they then assume a natural impossibility to account for the flexures of the strata in the phenomena of earthquakes and internal throes or pressure to uplift the mountain-axis. But those folds and deep basins must have been formed naturally and gradually as the current subsided in certain directions, and as the surface of the earth generally contracted by the condensation of its materials. When we consider how much the tire of a wagon-wheel contracts on cooling, we can form some idea of what the contraction of the crust of the earth must be. This contraction first tends to eject the fluid matter of the interior in volcanic violence. But when the exterior crust has expended its heat and ceased its condensation, the continued contraction of the interior crust, or condensation of the liquid mass forming the great bulk of the earth, the exterior strata must yield in folds, depressing or rising as the interior condenses. If this effect was common to all parts of the earth's crust, and evenly distributed over the surface, the undulations would not be so great. But such is not the effect, since the weakest points are always folded first, and the deepest basins are always made deeper by the same cause, on the same principle, that it is easier to bend a weak sapling already partially bent, than to bend a tree that is strong and straight.

air and in the waters. Until this period there could have been no possibility of its return to the earth in large quantities by condensation, precipitation, or through animal or vegetable life. The heat that vaporized it still prevented its condensation: therefore, both the atmosphere and the waters must have been surcharged with carbonic acid, which, during the first cessation of volcanic heat and violence, returned to the earth in the shape of lime. Such is the natural process; and such, we may observe, must have been the cause and result during the formation of the second or great carboniferous limestone.

We may not reiterate here the successive formations of the Palæozoic strata, as described in Chapter II., but we must notice the fact of a frequent recurrence of volcanic action and violence from the first to the second great limestones. It was intermittent, however, and more or less violent through a long series of formations of sandstones, slates, shales, and limestones. In those formations we find the carbon preserved in available form in the shape of carbonic acid in *lime*, and hydrocarbon in *petroleum*. From the first great limestone to the base of the coal measures, more or less of the hydrocarbons was preserved in the limestones and bituminous shales. But it must be remarked, in explanation of its absence in certain locations, the hydrocarbons do not exist in formations which admit of their escape in gas; nor were they formed at the period of those precipitates in which they are found, but were the production of subterranean gases since.

We may now pass over the subsequent periods following the formation of the great limestone to the immense sand-rocks of the "old red" and the subcarboniferous, which, again, must have been produced by heat and violence, followed, as before, by quiet and a reduction of temperature; and the result, as before, was the production of lime.

There is a singular and unaccountable circumstance connected with the carboniferous lime which claims our attention. In the east and northeast of the Alleghany basin, the subcarboniferous strata are the well-known *red shales* of our anthracite coal-fields, but to the west it is the carboniferous limestone. The one gradually takes the place of the other; the lime thinning to the east and enlarging to the west, while the other thins to the west and increases to the east.

Prof. Rogers accounts for this change in the assumption that the lime was peculiarly a marine production, and came in from the southwest; while the Red Shale, or "Umbral," was a shore or land production, and came from the east. This seems plausible; but we cannot imagine why the same rule did not work during the formation of the first or Auroral limestone, which is, perhaps, thicker on the east than elsewhere!

There can be no doubt but the amount of lime in the red shale is equal to the average deposit where the red shale commences to thin, or even

where it does not exist; that is, the amount of lime in the red shales of the east is equal to the lime formations of the west under equal areas.

However we may account for the change from shale to limestone, or *vice versâ*, we know that both must have been formed in a quiet sea and during a season of comparatively low temperature, since the greater portion of the shale is a soft, red mud of almost impalpable fineness, and has been evenly deposited in the most conformable manner as an aqueous sediment.

THE GREAT CONGLOMERATE.

The formation next in order of deposit in the waters of the ancient sea is the great Conglomerate, which is the floor and base of the coal measures. This formation, like all the strata of the Appalachian basin, excepting the lime, is in vast preponderance in the east, particularly in the vicinity of the anthracite coal-fields. Here it is over 1000 feet in thickness along its lower border, but thins off rapidly in a western direction. On the western outcrop of the Wyoming coal-field it is about 100 feet thick; and on the eastern escarpment of the Alleghany, in the same direction west, it is not over 30 feet; while throughout the Western coal-fields it ranges from 10 to 15 feet.

There are several theories regarding this extraordinary formation. It is composed of a conglomeration of pebbles, chiefly of a white quartzose character, but is made up otherwise of a great variety of rocks in pebble shape, cemented by arenaceous and argillaceous material of all ages except the primitive. Prof. Rogers thinks it the drift or wash of some ancient current, sweeping with great force from the southeast, or "towards a point a little west of north," evidently the ocean-tides.

There are circumstances which substantially support this conclusion, such as the general water-worn character of the diversified and imbedded pebbles, the intervening strata of shale and sandstone, and the want of uniformity in the strata and composition of the conglomeratic rocks. It evidently could not have been of volcanic origin, since there appears to be little or none of the pure igneous rocks in the mass, but all came from the subsequent sedimentary formations.

The conglomerate must have been formed immediately after the carboniferous limestone, and perhaps partly cotemporaneous with it. The commotion of the tides along the eastern coasts, and the different conditions of the water, prevented the formation of lime, or precipitated it among the enormous mass of shales and conglomerate which has taken its place in the East. The carboniferous lime is 200 feet thick at Pittsburg, while the Umbral red shale is 3000 feet thick at Pottsville, and intermediate the same proportions will hold good, since both the shale and the lime thin in the same ratio. Thus, if the limestone contains, on an average, 45 per

cent. of carbonate,—which it does not,—the Umbral would absorb the whole with an imperceptible proportion of 3 per cent. of the carbonate of lime.

We also notice the absence of bituminous matter in the formations of the East, which evidently could not have been for the want of carbon; but the conditions which then and subsequently existed were different from those of the West, and, consequently, not only one but all formations have felt the resulting change.

The only reasonable theory in contradiction to the foregoing, in regard to the formation of the conglomerate, is that they are, or may be, water crystals or concretions; but the evidence against this theory seems to be conclusive, and we need not present the arguments of the theorists.

Fig. 5.

CONGLOMERATE ROCK.

COAL FORMATIONS OF THE ANCIENT BASIN.

We have now, step by step, from the deepest formations which have filled the Appalachian basins, arrived at the upper and most magnificent, which crowned the whole and finished this stupendous creation of Nature.

We have seen how the vast and unfathomable gulfs of the ancient sea were filled by the molten lava which poured from the long chain of granite and volcanic hills that formed its steep and gigantic coast-line on the east, and perhaps from volcanoes in its centre; how the vapors of combustion—the escaping carbon—were collected and stored in the limestones and shales and sealed for future use; how the great basin was filled and levelled by later and finer deposits in preparation for the life and vegetation which was to follow.

It will be necessary to review at some length the form and structure of the Appalachian basin as prepared for the production of mineral coal, since the natural process here resembles, and was, in fact, the same as that which produced coal elsewhere; and a plain statement of the circumstances which come beneath our knowledge and comprehension in this case, will present a general exposition of the formation and origin of all the coal of the Carboniferous era.

It will scarcely be necessary to state that the limits of the ancient sea

were at this period largely contracted. The enormous mass of material which filled up the eastern edge of the basin, being vastly in excess of that carried by the waters towards the interior, naturally elevated the eastern shores and drove the waters back, thus forming a long line of new shore, parallel with the old granite range, and of great width,—extending, for instance, in Southwestern Virginia, over a distance of 150 miles, or from the granite hills of North Carolina to the eastern escarpment of the Alleghany in Western Virginia. This was general along the eastern edge of the basin, though much narrower at some points than others; the anthracite fields of Pennsylvania being the most eastern, and, of course, nearest to the original granite boundary of the ancient sea. But even here the new line of shore could not have been less than 50 miles from the Sharp Mountain to an indefinite point south of the Blue Ridge or Reading Hills.

The sea was driven back by the constantly encroaching land, the production of volcanic action. But in order to explain its elevation as dry land along the newly erected coasts, we must assume the depression of the interior and the gradual subsidence of the waters. This, however, is not a mere inference. Prof. Rogers demonstrates this clearly in his theory of the origin of coal; and so many evidences are offered of the fact, that we state it as such.

We now find, instead of the vast Appalachian ocean, an inland basin of comparatively contracted limits, with rivers draining the new continent, as the New River now drains that portion which preserved its original physical features. The St. Lawrence, the Hudson, the Delaware, the Susquehanna, the Potomac, and the James did not then pass their waters towards the Atlantic, but flowed in unknown courses towards the great inland sea. The St. Lawrence brought down the accumulated waters of the north, with their vast debris, along the eastern coast. The ancient Missouri then, as now, rolled its muddy waters to the south.

It will not, under such circumstances as these, appear strange or wonderful that the great Appalachian Sea no more exists; but it would be strange if those accumulating waters, rolling down over soft and imperfectly formed strata, did not fill up the shallow sea.

The physical changes in the drainage and topography of the eastern edge of the Appalachian strata are due to subsequent events. The anthracite basins were part and parcel of the great Appalachian coal-field, and formed in the same manner and at the same time with the bituminous coals of the West.* The intervening space might not have been occupied by a continuous coal-field; but we have existing evidences, in the many outlying patches of coal and conglomerate, to prove that the larger portion of the now denuded area was at one time occupied by coal formations; and the fact of their denudation by eastern waters is a positive evidence of

* The causes producing anthracite are explained further on.

the change in topography after the formation of our coal-fields. Consequently, the waters must have flowed to the west until this period.

We noticed the causes of this physical change in the commencement of this chapter; but it may appear plainer in this than in that connection. The gradual subsidence of the earth's crust was general at the period of which we write,—or during the coal era,—at the close of a season of constant and violent volcanic action, and enables us to account for our coal formations, we think, in a plain and practical manner, which could not be done under any other hypothesis.

But the rapid subsidence or greater depression in the eastern synclinals, or valleys, requires some definite explanation. As we before stated, a long line of granite shore runs parallel with the ancient Appalachian sea, and with the present range of Appalachian mountains; and the probability is that not only one but several ranges of the same kind originally existed along the bottom of the ancient sea, corresponding to our present flexures or mountainous folds; since the early dynamic effects of internal forces seem to have been in long parallel lines,—a fact attested by the physical features of the earth, which always exist in long lines of mountain and valley, except when changed and distorted by central volcanic influences.*

This form of topographical structure being demonstrated,—as, we think, all the facts hitherto given do fairly demonstrate,—we may next allude to the fact that the eastern portions of the ancient sea must have been vastly deeper than the interior, as before stated and proved. These facts being accepted, we are now prepared to offer a plain solution of the problem of inverted strata, and the deep synclinals of our eastern basins.

In the first place, these deep axis of formation must have been originally the weakest part of the earth's crust; in the next, they were in close

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* "As a general fact, volcanic vents are arranged in extensive lines or zones, often reaching half around the globe.

"Perhaps the most remarkable line of vents is the long chain of islands, commencing with Alaska, on the coast of Russian America, which passes over the Aleutian Isles, Kamtschatka, the Kurilian, Japanese, Philippine, and Moluccan Isles, and then, turning, includes Sumbawa, Java, and Sumatra, and terminates at Barren Island in the Bay of Bengal. Another almost equally extensive line commences at the southern extremity of South America, and, following the chain of the Andes, passes along the Cordilleras of Mexico, thence into California, and thence northward as far at least as Columbia River, which it crosses between the Pacific Ocean and Rocky Mountains."—*Hitchcock's Geology.*

The number of active volcanoes on the globe is estimated at 407. Of these, 52 are in North America, 48 in Central America, and 54 in South America.

The eruption of Kilauea, in Hawaii, during 1840, is a good example of the effects of molten lava when poured into the sea, and also of the nature of the sediment it would form. A stream of molten lava, half a mile wide and 20 feet thick, poured in one vast cataract of fire, over a precipice 50 feet high, into the sea, with fearful hissing and loud detonations. The atmosphere, in all directions, was filled with ashes, spray, and gases; while the burning lava, as it fell into the water, was shivered into atoms, and, being thrown back into the air, fell in showers of *sand* on all the surrounding country.

proximity to the active volcanoes of the plutonic regions of the coast, and the spasmodic venting of incessant streams of lava, which filled the vast extent of the Appalachian Sea, must have tended to cause a *vacuum* in the bowels of the earth; and, as "nature abhors a vacuum," nothing can be more natural than the subsidence of those deeper basins, in the vicinity of this constraining cause.*

The inverted strata or flexures of the Alpine formations have the same form and feature, and were evidently caused by the same volcanic action. But this cause could only operate during the continued action of volcanic influences; and there has evidently been a continued subsidence of those deep basins since the formation of our coal-fields, which needs further explanation.

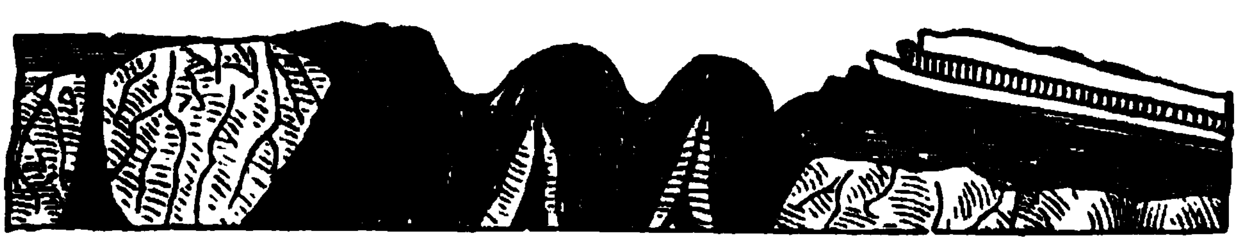
The magnificent formations of anthracite in Pennsylvania could not have been created in their present form. No deposit could have taken place on the perpendicular strata which accompany it, in many places, or on the anticlinals which are folded back on the edges of the basins.

The basins in which the original deposit took place must have been of comparatively gentle undulation,—deeper, perhaps, and of steeper angles of dip than the great bituminous basins of the West, but having no comparison to the present inclinations.

It has been stated and demonstrated in the previous pages that the weakest portions of the earth's crust are in the vicinity of active volcanoes; but in the present instance circumstances existed to make this vicinity still more susceptible to the influences of internal violence, and the irresistible forces of condensation and contraction going on in the crust of the earth.

Of all mechanical powers, there are none so tremendous and irresistible as the two we have given in illustration of the natural processes which tend to change and modify the physical geology or the lithological structure of the earth,—that is, VACUUM and CONTRACTION.

FIG. 6.



"LATERAL CONTRACTION."

The above illustration represents the action of *lateral contraction*. The amount of contraction in the earth's crust is collectively very great, but the conformation of the Appalachian strata was such as to concentrate its contraction to a single group of formations, along its weakest line of crust, which passed in the vicinity of the anthracite coal-basins.

From the centre of the Appalachian formation to the eastern escarpment

* Sir Charles Lyell advocates this theory of subsidence and consequent flexure.

of the Alleghany, the formation is very thick, and generally on a plane slightly varying from the horizon. The flexibility of this level mass of strata, which was, and is, perhaps, from 20 to 50 miles thick, could not have been in proportion to the already flexed and weakened basins of the East; consequently, the contraction or condensation towards the centre of the earth must have been exerted laterally and against the weak and already partially folded strata of the eastern basins. It must be understood, in this connection, that we are not speaking of the local contraction of the surface strata, because they had already reached their maximum of condensation. It is now the contraction of the interior crust, or the condensation of the liquid mass of the earth, that we are treating of.

We think this illustration will sufficiently demonstrate the causes and processes which effected the violent contortions and steep angles of our eastern basins. The action was gradual, as it was irresistible, and therefore produced no great rents of fissures in the strata, but exerted its crushing influence through a vast space, and left the evidences in innumerable slides, cracks, and cleavages throughout the strata affected.*

We have now reached a point where we can satisfactorily contemplate the natural processes by which our magnificent fields of coal were produced, having, to our own mind, clearly demonstrated the facts or the hypothesis we set forth to prove.

Nature had prepared for the closing glory of her Appalachian monument. The great Appalachian Sea had been contracted to less than one-half its original superficial area, and its present shallow depth bore no comparison to its former unfathomable abyss. Its shores were now quiet, low, and clothed in verdure. Long receding shores, without cliff or mountain, stretched gently away towards the ancient coasts, from which now came vast rivers, rolling in the mud and drift of the soft and imperfect strata which had never been condensed by pressure and not yet hardened by exposure and time; and, thus prepared, we leave the *formation* and *origin* of coal for the following chapter.

* Sir James Hall, Sir H. De La Beche, and other geologists, advocate this theory of contraction and consequent foliation or flexure of strata. Lateral contraction will be more fully explained in Chapter XIV.

CHAPTER IV.

THE FORMATION AND ORIGIN OF COAL.

The Carboniferous Era—The Acme of Vegetation—The Coal Flora—Hugh Miller's Description—Aqueous or Terrestrial Vegetation—Formation of Coal—Time required to form a Coal-Bed—Arborescent Growth—Peat-Bogs—Nature a Busy Worker—The World not so Old, after all—The Coal Measures—Subsidence of the Land—Fluvial Deposits—Volcanic Eruptions—Terrestrial Vegetation in the Rocky Strata—Theories of Coal Formation—Vegetable Hydrocarbons—Coal-Basins—Carbon—Naphtha—Petroleum—Bitumen—Anthracite—Diamond—Coal and Coal-Oil—Anthracite Coal Formations.

In the preceding chapter we presented the Appalachian basin as it existed at the commencement of the Carboniferous era, when the violent volcanic action of that portion of our continent had ceased or become intermittent, and the great depths of the ancient sea had been filled with the early Palæozoic rocks, leaving but a shallow sea and a soft, low shore for the base of the new and wonderful formations which had now commenced. But, though the violence of eruptive volcanoes could not now pour the molten lava over the new shores, volcanic action and internal heat still had much to do with the subsequent formations.

It was yet early in the creative periods. The "*third* day," as described by the Mosaic account, had not yet closed, and air-breathing animal life had yet no existence. The air was full of vapor and the floating dust of distant eruptions; carbonic acid loaded the waters and surcharged the air; a sulphurous and heated atmosphere everywhere encircled the earth; and the waters were tepid with the radiating heat of cooling lava and the condensing earth.

The temperature that then existed would be insupportable to terrestrial animals, while the carbonic acid that impregnated the air would be destructive to common air-breathing creatures. The vapors of carbon still arose from a thousand sources,—smoking volcanoes and smouldering lava; and every crack and fissure of the earth still poured forth its volumes of the vapors of combustion, which here, in the contact with water, formed carburetted hydrogen, and there, with the atmosphere, formed carbonic acid.

Such a coincidence of favorable circumstances could not fail to produce a vegetation of the most vast and magnificent description, in comparison with which the most luxuriant of the present day would be as a "drop in the bucket." The soft and fertile soil, made rich with the decaying matter of the ancient marine life and the resulting bitumen of the carburetted hydrogen gases; the atmosphere, warm and moist with heat and steam,

and loaded with the life-giving carbon so necessary to vegetation, all tended to invigorate and give an unlimited growth to that early flora.

This was the acme of vegetable life. Hitherto those favorable circumstances did not exist, and vegetation could only have flourished to a limited extent.

During the subcarboniferous era, which followed the "*old red*," or the vespertine, we have noticed an uncertain and meagre *coal flora*, but in only one instance, in a limited area, was a coal of commercial value produced in this country.* Yet the time that transpired from the vespertine, or *proto*-carboniferous, to the *true* carboniferous, was comparatively limited; the red shale, or carboniferous lime, and the conglomerate formations, only intervene.

In tracing the production of the ancient or fossil flora to a later date than the Carboniferous, we also find a great depreciation; and though occasionally limited fields and thick coal-beds were formed, they are generally both limited in area and in thickness of bed.

Having thus carefully traced the processes of Nature to this remarkable and wonderful period of the earth's existence, we are now, in a measure, prepared to appreciate and comprehend that which is to follow; though we shall still be *theorists*, notwithstanding the facts, for we get, after all, but dim and uncertain glances into the arcana of Nature. But we have the satisfaction of knowing that our theories are plausible, probable, and consistent with existing facts and evidences, and that neither miracle nor unnatural processes are required to prove the hypothesis.

THE COAL FLORA.

We have before us "a low shore thickly covered with vegetation. High trees of wonderful form stand out far into the water. There seems no intervening beach. A thick hedge of reeds, tall as the masts of pinnaces, runs along the deeper bays, like water-flags at the edge of a lake. A river of vast volume comes rolling from the interior, darkening the water for leagues with its slime and mud, and bearing with it to the open sea, reeds, and fern, and cones of pine, and immense floats of leaves, and now and then some bulky tree, undermined and uprooted by the current. We near the coast, and now enter the opening of the stream. A scarce-penetrable phalanx of reeds, that attain to the height and wellnigh the bulk of forest-trees, is ranged on either hand. The bright and glossy stems seem rodded like Gothic columns, the pointed leaves stand out green at every joint, tier

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* The flora to which we allude grew on the New River, Southwestern Virginia, in the vicinity of the great limestone, under circumstances more favorable than usual during that period. It was an elevated locality. The water must have been shallow, and the soils soft and rich.

above tier, each tier resembling a coronal wreath or an ancient crown, with the rays turned outward; and we see atop what may be either large spikes or catkins.

FIG. 7.

THE COAL FLORA.

"What strange forms of vegetable life appear in the forests behind! Can that be a club-moss that raises its slender height for more than fifty feet from the soil? Or can these tall, palm-like trees be actual ferns, and these spreading branches mere fronds? And then these gigantic reeds! are they not mere varieties of the common horse-tail of our bogs and morasses, magnified some sixty or a hundred times? Have we arrived at some such country as the continent visited by Gulliver, in which he found thickets of weeds and grass tall as woods of twenty years' growth, and lost himself amid a forest of corn fifty feet in height?

"The lesser vegetation of our own country, its reeds, mosses, and ferns, seem here as if viewed through a microscope: the dwarfs have sprung up

into giants, and yet there appears to be no proportional increase in size among what are unequivocally its trees. Yonder is a group of what seem to be pines, —tall and bulky, it is true, but neither taller nor bulkier than the pines of Norway or America; and the club-moss behind shoots up its green, hairy arms, loaded with what seem catkins, above their topmost cones.

"But what monster of the vegetable world comes floating down the stream, now circling round in eddies, now dancing on the ripple, now shooting down the rapid? It resembles a gigantic star-fish, or an immense coach-wheel divested of its rim.* There is a green, dome-like mass in the centre, that corresponds to the nave of the wheel or the body of the star-fish; and the boughs shoot out horizontally from every side, like the spokes of the nave, or rays from the central body. The diameter considerably exceeds forty feet; the branches, originally of a deep green, are assuming the golden tinge of decay; the cylindrical and hollow leaves stand out thick on every side, like prickles of the wild rose on the red, fleshy, lance-

FIG. 8.

FOSSIL PLANTS.

like shoots of a year's growth, that will be covered two seasons hence with flowers and fruit. That strangely-formed organism presents no existing type among all the numerous families of the vegetable kingdom.

"There is an amazing luxuriance of growth all around us. Scarce can the current make its way through the thickets of aquatic plants that rise thick from the muddy bottom; and though the sunshine falls bright on the upper boughs of the tangled forest beyond, not a ray penetrates the more than twilight gloom that broods over the marshy platform below.

"The rank steam of decaying vegetation forms a thick blue haze, that partially obscures the underwood. Deadly lakes of carbonic acid gas have accumulated in all the hollows. There is a silence all around, uninter-

* Since discovered to be the roots or base of the gigantic Sigillaria, which always grew in the fire-clays of our coal-beds, and therefore could not float down the river into the coal area.

rupted save by the sudden splash of some reptile-fish that has risen to the surface in pursuit of its prey, or when a sudden breeze stirs the hot air and shakes the fronds of the giant ferns or the catkins of the reeds.

"The wide continent before us is a continent devoid of animal life, save that its pools and rivers abound in fish and mollusca, and that millions and tens of millions of the infusoria tribes swarm in the bogs and marshes. Here and there, too, an insect of strange form flutters among the leaves. It is more than probable that no creature furnished with lungs of the more perfect construction could have breathed the atmosphere of this early period and have lived."*

The above description by Hugh Miller is perhaps the best we have of the form and character of the ancient coal vegetation. But the late attempt to make our mineral coal the product exclusively of an arborescent flora is not consistent with the facts or the nature of things; and we are forced to return to the marine flora as part of the formation, before we can reconcile all the coincidents of our fossil vegetation to the production of coal.

All our known coal-fields have a basin-shape, while the angles of the strata dip to a common centre. If non-conforming coal strata exist, it is due to local and subsequent causes,—denudation and unequal movement of the superincumbent strata.

Consequently, all our coal-fields must have arisen out of *basins*, *lakes*, or *seas*, and, of course, from or in the water. That the vegetation grew entirely *in* the water, however, is not evident: the contrary would *seem* to be the rule, if we accepted the fossil flora of the *coal-slates* and *rocks* as evidence that they also formed coal; since nearly all the species of fossil flora found in those rocks are of land origin. But in close proximity to the coal we find the remains of a gigantic vegetation, that evidently sprung from the deep mud of those shallow seas. In the coal itself we find no positive existence of vegetation,—no trace of leaf or stem. But the vast forms of the *Sigillaria* and its enormous base of roots, the *Stigmaria*, are profusely abundant in the fire-clays of all our coal-beds, and particularly in the lower series. Here also the towering *Lepidodendron* and the gigantic *Calamite* had their existence. They and their species form the chief remains in the strata of the lower veins, and exist exclusively in the beds of *fire-clay* supporting the coal, while their stems and leaves and branches are found in abundance through the slates which immediately overlie the coal. We are therefore to infer that they formed the mass of our lower beds at least, if we are to concede that a pure vegetation formed our existing beds of coal, which is doubtful, as we shall show.

Our coal-beds are of vast extent, and we find some of the upper seams existing over 14,000 square miles, without a single break or discontinua-

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* Hugh Miller's "Old Red Sandstone."

tion of strata, while, in all probability, the lower seams will be found to underlie the entire Alleghany coal-field, without a positive discontinuity except where cut off by the streams and such local and subsequent causes.

Therefore, unless we admit that most of our coal vegetation took root deep in the water, we must assume that all the vast area of over 70,000 square miles was level and one vast marsh, which is in contradiction to all fact and in violence to every natural process that we can conceive; and those who advocate this and claim an exclusive arborescent or land vegetation as producing coal must summon to their aid *earthquakes* and prodigies of Nature for every coal-seam existing, in order to reconcile their theory with the facts.

We have no reason to believe the sea which gave growth to the ancient flora was deep: on the contrary, it was a shallow sea, and from the mud of its bottom—our present *fire-clays*—sprung up the long, grape-vine-like *Sigillaria*, and Lepidodendra, and the gigantic Calamites.

In that tepid water they soon reached the surface, and spread out, a vast sheet of luxuriant vegetation. The waters were impregnated with hydro-carbon, and its surface, loaded with the heavy carbonic acid gas which gave such prodigious energy to the vegetable growth, came in contact with its vapors. We cannot imagine a more favorable condition for an unlimited growth, since no change of atmosphere, no rigid winter, came to check its vast increase, and the superabundance of carbon prevented its decay. Instead of 1000 years being required to form a coal-bed (3) three feet thick, it did not require as many months,—perhaps not as many weeks.

This vegetation was not solid wood, such as we now find in our forests, but rank fronds or sappy vines, full of carbon or resinous and oily juices, containing, in fact, more of the solid matter of coal than our most solid trees of to-day.

There could scarcely be a limit to the size of the coal-bed that might thus be formed but its own weight or a subsidence of the basin; and thus we can readily account for the benches in our large coal-beds, none of which are over three or four feet thick. The immense amount of vegetation gradually sinking under water, as it formed, and becoming heavy with water, carbon, and bitumen, would eventually sink to the bottom, but immediately the vines shoot up again to the surface, and the process is repeated, each time forming either a thin slate or a band of imperfect coal, as circumstances might determine. Sometimes even the surface of this mass of vegetation might be covered with a layer of ashes, soot, &c., from the discharge of distant volcanoes,* and produce the same result. It might be interesting to calculate the immense amount of vegetation it would require to form a vein of coal equal to the Mammoth.

* Ashes and sand have been carried from 200 to 1000 miles from violent volcanic eruption. See further in this chapter.

If we take an average forest of our present day as the base of our calculations, we find that an acre of ground containing 65 trees, each averaging 240 cubic feet of solid timber to the tree, or five tons, and containing 20 per cent. of carbon, will produce 65 tons of charcoal; or it would require 74 such forests to produce a bed of coal *one foot thick*, which contains 4840 tons of coal. To pursue the subject further, we may assume such a forest of white oak to have been one hundred years in coming to perfection, and we thus find that it would require 7400 years of our present forest growth to form a bed of coal (3) three feet thick; or 74,000 years to accumulate the mass of coal existing in our 30-foot Mammoth coal-bed.

We may indulge in some speculation as to the relative time required to produce the same result during the ancient flora. We find the heat, the moisture, the carbon, and the water, all combining to produce an excessive growth; and we may safely assume that each year of such growth would add one foot to the thickness of the vegetable mass, as before described. This might be compressed, in the shape of coal, to one-fifth its bulk or weight, and all that it would lose in the slow combustion, or process of charring, in the bowels of the earth, would be more than supplied by the accession of carbon and hydrogen from the subterranean vapors still pervading the earth, air, and water. This would require five years to produce *one foot of coal!* or 180 years to form the 30-feet coal of the Mammoth.

We cannot conceive of any other natural process by which our large veins of coal could be formed direct from vegetable matter.

If we assume the vegetation to have been arborescent and the peculiar fossil flora of the land, we cannot possibly accumulate a sufficient mass, by any theory, to produce a three-foot vein of coal. Growing on the land, and, consequently, in the air, the growth of successive years could not have been preserved, and the growth that could have stood on the place where it grew, could not have formed one of our smallest available coal-beds.

If we assume the vegetation to have been of the peat, or bog, order, we must admit the whole of the vast area of our Appalachian coal formation to have been level, and the gradual subsidence of the land would then conform, in part, to the requirements of the facts sustaining the theory. But even they who sustain this theory of *peat-bog* formation require the growth of 1500 years to form the ten-foot Pittsburg seam.

We do not believe that Nature worked so slow. At this rate of progress it would require 15,000 years to form our 100 feet of anthracite coal, or perhaps ten times that period to deposit the 3000 feet of coal measures in which this coal is stratified; while the total thickness of the fossiliferous strata, from the azoic to the cainozoic, would require the lapse of millions of years. Such a state of progress is unnecessary, unnatural, and not consistent with the facts.

We have no doubt that the mighty work of creation was accomplished

in far less time than our present data would indicate; we cannot judge of the productions and processes of the past by the present.

Tracing the process of Nature in filling the great Appalachian basin with strata upon strata, we have no reason to think that numberless ages transpired during its accomplishment. The rivers of molten lava poured out by a hundred volcanoes would accumulate the mass in a comparatively short space of time. It may be argued that such could not have been the real nature of the process, in view of the animal life that then existed. But it is evident that no other cause could effect the mighty change from an unfathomable ocean to a vast continent; and, therefore, such must have been the cause and effect to a greater or lesser degree. The low order of animal life then existing was only found in strata which indicate repose and quiet; they therefore sprung into existence during every short period of rest, and vanished with the return of violence and change, as the many palæontological breaks in the ancient strata indicate unequivocally.

Whether the theory of the water vegetation—which we may term "super-aqueous," since it really grows above the water, while its roots are below it—or the peat-bog formation be accepted, or, in fact, any other, the same subsidence of the land and the same changes of condition are required to account for the intervening strata of slate and rock which form our coal measures. In the former, however, the subsidence of the land is not a positive necessity to account for the superincumbent strata, since the vegetation filling the water would be crushed down by accumulating earthy matter, and the sedimentary process and the formation of coal-beds might go on without the necessity of a gradual or an intermittent subsidence. The question is, whether or not the tall vines of the *Sigillaria*, &c. could reach the surface from the vast depth of 3000 feet, or the total thickness of the coal measures. We do not think the proposition at all probable, since the evidences of a gradual subsidence of the interior basin, or perhaps the entire Appalachian formation, is overwhelming and unequivocal.*

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* We may notice a fact which will prove either the one or the other, viz.: the subsidence of the interior of the basin, or the formation of coal in deep water.

The highest bed of coal at the Portage Summit, on the line of the Pennsylvania Railroad, is 2300 feet above tide, while the *same bed*, at Johnstown, 17 miles west, is 1200 feet below the portage level.

The elevation of the strata in Northwestern Pennsylvania, at the head of the Alleghany River, is 1500 feet above the same strata at Pittsburg; while the coal in the mountains of West Virginia, along the eastern borders of the field, is between 1500 and 2000 feet above the same beds on the Kanawha, at Charleston, and the coal of Lookout Mountain is 1000 feet above the Tennessee River at Chattanooga, or above the same beds on the Ohio. To the west and northwest the elevation is much less. But the coal on the Shenango, at Sharon, Ohio, is 250 feet above its level on the Ohio at Pittsburg.

The anticlinal bounding the great Alleghany coal-field to the west, or between this field and the basin of Indiana, is low and broad, but still elevates the outcrop considerable above the same beds towards the centre of the basin. This anticlinal runs from Lake Erie

We may consider for a moment the conditions and changes which resulted from a subsidence of the land, or a depression of the vegetation forming a distinct coal-bed,—the process by which the superincumbent strata formed, and the inauguration of a new growth of vegetation.

The subsidence of one portion of the earth must either result from its contraction or condensation, or from volcanic eruptions: the latter cause we must presume to have been the prevailing one during this early period; and the existence of long lines of constantly active or intermittent volcanoes on either hand, to the east and west, gives ample evidence of the fact.

But whether the result was the effect of one or the other of those causes, the formation of the superincumbent strata would be much the same. In the one case it would be slow and slaty, or the sediment would be fine and argillaceous; while in the other and later it would accumulate rapidly and be coarse and arenaceous. The first, resulting from the debris of older strata brought in by rivers and floods in a comparatively quiet manner, forms slates, shales, and limestones; and the second, resulting from violent commotions, would not only cause the accumulation of strata from the sources of the first, but would receive vast acquisitions from the floating ashes, sand, and dust of not very distant volcanoes.*

The formation of the upper series of coal measures was evidently more slow than the lower series, as the coarse arenaceous rocks are but few in number, while the slates and shales are profusely abundant. This type, however, of the general character of the great Appalachian region has an exception in the isolated anthracite coal basins of Pennsylvania, since the coarse strata here exist to the top of the coal measures: still, even here we find the material finer in the late than the early formations. The anthracite basins existed in the vicinity of active or intermittent volcanoes, and derived most of the rocky strata from these sources.

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to Alabama. It is simply a broad axis, or anticlinal, running through the great basin, on the same principle as the dividing anticlinals in our smaller basins. The true outcrops, or western extremity, of the great Appalachian formation, is at the base of the Black Hills, or the eastern foot of the Rocky Mountains.

* "Probably the most remarkable eruption of modern times took place in 1815, in the island of Sumbawa, one of the Molucca group. It commenced on the 5th of April, and did not entirely cease until July. The explosions were heard in Sumatra, 970 geographical miles distant, in one direction, and at Ternate, in the opposite direction, 720 miles distant.

"So heavy was the fall of ashes at the distance of 40 miles that houses were crushed and destroyed beneath them.

"Towards Celebes they were carried to the distance of 217 miles, and towards Java 300 miles, so as to occasion a darkness greater than that of the darkest night. On the 12th of April the floating cinders to the westward of Sumatra were two feet thick, and ships were forced through them with difficulty. Large tracts of country were covered by the lava, and out of 12,000 inhabitants on the island only 26 survived."—*Hitchcock's Geology.*

During the eruption of Cosiguina, in Guatemala on the Pacific, in 1835, ashes fell in Jamaica, 800 miles eastward, and upon the deck of a vessel 1200 miles westward!

In this connection we may notice several singular facts, which somewhat impair the best theories of fossil coal vegetation. Of all the millions of specimens appertaining to a thousand or more species of fossil flora found in the coal measures, but few have been found *in the coal.* They are generally found in the clays, slates, shales, and sandstones above or below the coal; consequently, as those measures were formed from the debris of the land, the flora found in them would be of terrestrial growth. But it does not follow that the *coal* must be of the same vegetation, since the theory of *drift* cannot be entertained in the consideration of its production. The only species of vegetation found in such close connection with the coal as to warrant an assumption of their being the coal-producing flora, are the deep, water-rooted *Sigillariæ, Lepidodendra, Calamites,* &c., and their numerous species, growing up through the water and spreading on its surface, as before described.

But of all the fossil remains of the terrestrial flora we do not find one that has been changed to coal; and the same may be said of such marine vegetation as exists in the strata not in immediate contact with the coal. All the numerous fossil remains of the ancient arborescent vegetation are solidified into sandstones or limestones, or partake of the character of the slates and shales in which they are found. A few of the larger trunks of the Sigillariæ, Calamites, &c., have been found coated with a thin film of coal; but their bodies are always silicious or calcareous.

That these trees originally contained both carbon and bitumen there can be no doubt; and we are led to infer that these constituents of all vegetation must have been expelled either by pressure or heat; and if expelled in the shape of oil or bitumen, the results might produce coal; and thus, indirectly, the whole of the ancient vegetation would be economized in the formation of our mineral fuel; while the direct conversion of all the vegetation of the Carboniferous era into coal was an impossibility.

THEORIES OF COAL FORMATION.

It is a fixed law of nature that matter cannot become exhausted or depreciated in weight, though it may change from one substance to another. Carbon, being one of the simple substances of the globe, was diffused through all matter composing it, existing in the vapors of the atmosphere surrounding it, and in the solid portions of the earth; but during the early periods of the earth's existence, when the internal heat held the gaseous substances in vapor, the earth must have been shrouded by carbon and oxygen, as fixed air or carbonic acid; and the manner or condition in which it has been condensed and solidified is admirable and wonderful, evincing an economy in the processes of nature that we must consider as providential and with a view to subsequent results.

It has been preserved as lime, coal, bitumen, and oil, as we have noticed in the foregoing pages. But how, or in what form and manner, is the subject of the present thesis. It has been inferred that all carbon returns to the earth in the shape of vegetation; and we admit that as a fact now, when our atmosphere contains only one-thousandth part of carbonic acid; but when the atmosphere was surcharged with heated vapors, and carbonic acid, being the heaviest, shrouded the earth, the early vegetation, however great, could not have absorbed it, and it returned, as we have seen, in connection with the salts of calcium and magnesia, forming lime.

It is evident, however, that a large amount of carbon was taken up by the early vegetation of the coal era, which we cannot lose sight of, and which must be accounted for. As we before noticed, this vegetation did not appear to form coal in a direct manner, but the carbon it contained was distilled or expelled, by pressure and heat, in the shape of oil, which must have been a carburetted hydrogen; and this would form coal.

Those processes would form coal rapidly and in great bulk. The aqueous vegetation and oils of vegetation and gas combined, or either one of them, would produce the same result more slowly. But both of these processes must have been carried on in water. In fact, the evidence is overwhelming that our coal-fields were formed in basins of water,—lakes, seas, or oceans; and every practical theory of the production of coal requires this condition, to reconcile the coincidences and detail which meet the eye of the miner.

The disposition and formation of the rocky strata forming the coal measures are the same in all cases and the result of the same causes.

This theory seems to prevail since the large development of our carbon oils, or petroleum, which is formed from subterranean gases, resulting from the action of heat and water on the carbon of the rocks,—principally limestones and bituminous shales. It exists in various forms. The naphtha of Persia is lighter than our petroleum, and is constituted of carbon 82.20, hydrogen 14.80; and our lighter or lower oils are of much the same consistency. The heavy or lubricating oil is denser and of a much thicker consistency. A third variety is still less fluid, and is known as maltha, mineral pitch, sea-wax, &c. It is of the consistency of tar, but is sometimes found in a pure state, resembling tallow, paraffine, &c. A fourth is called "elastic bitumen," and is nearly the same substance chemically as caoutchouc, which contains carbon 90, hydrogen 10. A fifth variety is known as compact bitumen, or asphaltum. It contains carbon, hydrogen, and oxygen in various proportions, according to locality and purity. It is found extensively diffused over the earth, and is apparently the result of solidified naphtha or coal-oil, since it is generally found when in large bodies near volcanic localities, as in Judea and Trinidad, but is rarely

found among the older or primitive rocks. It exists stratified or in veins among all the rocks, from the great or auroral limestone up.

There is a singular connection between asphalt and mineral coal and asphalt and lime. In its purest state it has the appearance of the most beautiful coal, and contains the constituents of coal, but with a larger proportion of bitumen than our best cannel. Asphaltic rock contains from 80 to 90 per cent. of carbonate of lime, and from 10 to 20 of bitumen. Pure limestone is devoid of bitumen, as pure coal is devoid of the carbonate of lime or the salts of calcium and magnesium; and both may have been formed in the same manner, but under different temperatures, and in combination with a greater or less amount of carbon and earthy substances.

The sixth variety of naphtha is cannel coal, which is simply solidified petroleum combined with vegetable matter. The eighth is our common bituminous coal. The ninth is pure anthracite coal, which is simply changed by heat to the purest mineral carbon except the diamond. Perhaps we may add the tenth variety as a limestone; but we do not wish to extend these speculations beyond a brief notice, since volumes might, and *will*, be written to prove or disprove them. Our purpose is simply to present facts in evidence of what has been advanced, or in support of the theory of the condensation of carbon oil as the primary and chief cause of the formation of coal-oils, bituminous matter, and our extensive beds of mineral coal.

The vapors of carbon escaping and mixed with the oxygen of the air form carbonic acid. This, solidified and deprived of its oxygen and in combination with the minerals calcium and magnesium, forms lime. Pure carbon condensed forms the diamond.*

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* Diamonds are always found in volcanic districts. They are simply condensed carbon; and we may arrive at the mode of their formation if we consider the pressure or force exerted by volcanic action. The height of Cotopaxi is 19,000 feet above the sea; the level of the molten lava in its heart below the sea-base of the mountain, we cannot conjecture. It cannot, however, be less than the height of the mountain. Now, Cotopaxi has projected matter 6000 feet above its summit, and once threw a stone of 109 cubic yards in size to the distance of nine miles. From this we can form a faint conception of the weight of the column which is lifted by the forces of contraction on the liquid portions of the earth, and find, too, the immense pressure that is exerted on both *vapor* and liquids at the base of the volcanic column. The height of this column would be not less than 44,000 feet, which, calculating the specific gravity of lava at 2.8, would be equal to about 3550 atmospheres, which, we presume, would condense the vapor of carbon and form the diamond, since those vapors must have existed or now exist in the bowels of the earth.

A diamond enclosed in a wrought-iron shell and subjected to a high heat will dissolve in carbon and change the wrought to cast iron. The same result will follow if anthracite coal is substituted for diamond; but the coal will leave a small amount of ashes, which the diamond will not. If pure oxygen be enclosed in a glass jar, the diamond can be reduced to carbonic acid by placing it among this oxygen and igniting it with a lens or burning-glass. On being ignited in oxygen it will burn with a bright and lambent flame until it is entirely consumed. Anthracite or charcoal will burn in the same manner and produce the same results, but leave a residue of earthy matter.

The gases or vapors of carbon arising through the pores of the heated earth, or direct from the bases of volcanoes in water, form carbonated hydrogen gas. Hydro-carbon oils and asphaltum, in connection with vegetation or the oils of vegetation, form bituminous coal, and anthracite under higher degrees of temperature.

The gases which arise from the action of internal heat on the carbonated rocks also produce carbonated hydrogen gas and coal-oils through the same process, but such oils are more highly charged with bitumen than the oils resulting direct from the vapors of combustion.

Thus in the economy of Nature there is no great complexity of operation. The carbon of combustion or the products of the heated earth are arrested by both air and water, and condensed to both liquids and solids, and, in connection with the carbons taken up by vegetation, form mineral coal.

COAL AND COAL-OIL.

Hydro-carbons, petroleum, or naphtha, are the condensed results of carbonated hydrogen gas,—either the direct results of volcanic heat, or produced by the action of internal heat on the carbonated rocks.

They were never surface formations, because their lightness would prevent precipitation; consequently, if formed on the surface, they would still exist on the surface, either as *oil* or *solids*, and could not, therefore, form our present subterranean deposits of petroleum.

As before stated, oils escaping to the surface or formed on the surface and exposed to water or air soon form solids, bitumen, coal, &c. We must, therefore, conclude that the gases forming our present supply of petroleum, or naphtha, are subsequent productions, formed since the deposit of the strata in which they exist, and produced by the action of internal heat, or the heat caused by pressure, on the carbon of the rocks. Those gases, confined and condensed, form a combination with the hydrogen of water, and the result is a hydro-carbon, or coal-oil.

The constant production of those gases in the deep recesses of the earth, from whence there is no adequate means of escape, keeps them in a high state of tension,—like steam in a boiler; and they therefore avail themselves of every crack or crevice which offers a means of exit. On arriving near the surface, the heavier portion of those gases again forms oil if arrested by water, with which, however, it does not mix, but floats on it.

At the base of Mount Vesuvius the vapors of carbon, escaping through the sea, form naphtha, which is seen floating on the water in great quantities.

The lowest stratum in which oil is found under our Western coal-fields

lies very near the great or Auroral limestone, and is, therefore, a much older and a much deeper formation than coal.

In the East, the Auroral limestone is 25,000 feet below the coal, and perhaps 10,000 feet below the rocks in which oil is known to exist. But so rapidly does the strata thin towards the west, the probability is that 3000 to 10,000 feet would be the maximum thickness in the Western coal-fields, from the conglomerate to the Auroral or Matinal limestone; while the interval contains the great Carboniferous limestone, and a world of thin limestone and bituminous strata, from the "old red" to the "Medina Sandstone."*

The lime-rocks must, under heat, give off carbonated gas; and there is every reason to believe the production of carbonated hydrogen gas, and consequently hydro-carbon, or coal-oil, must have been greater before the formation of coal than since, because the heat which appears to produce these gases was greater before than after the formation of the coal measures. If so, and we cannot doubt it, the flow of gas and oil into the great sea or basin now holding our coal must have been immense, and the formation of coal in connection with the magnificent vegetation of that period was the result. Such, we think, was an absolute condition or result of the natural processes of that era. Since the flow of oil into the waters, after the escape of its more volatile parts, would result in sedimentary bitumen, and moderate heat would only facilitate the process, as now exemplified in our petroleum refineries, and in which we find the solids are by no means an impure, earthy residuum, but the richest portions of the constituents of oil, we may therefore trace our coal-beds to the gas direct, without the mediation of vegetable carbon. But the fact that vegetation existed at the time in such great profusion, and in close connection with our coal-beds, and that the vegetable oils expelled by pressure and heat must have been in contact with the rock oils, indicates their combination in the production of coal. Nor can we overlook the fact that the air contained more carbon, in all probability, than even the luxuriant vegetation of that era could absorb; consequently, carbonic acid would be formed; but whether it would unite with the hydro-carbons to form coal, or with the metallic bases to form lime, is a scientific question that we cannot determine. It is known, however, that carbonic acid, solidified, forms a *snow-white* substance, which has none of the properties of coal, but intimately connects it with lime.†

In the beginning of this chapter we presented the theory of coal vegetation, not precisely as at present in vogue among geologists, but such as will conform to a natural process, and which can be explained or elucidated without the aid of earthquakes, convulsions of nature, or prodigious phenomena.

* See Fig. 117,—the Great Basin. † Dr. Ure.

If we have expressed ourselves clearly, it will be found that no conflict exists in the two theories of coal formation here presented, viz.: that of *vegetation* and that of the *condensation* of naphtha, but, on the contrary, the one is an auxiliary to the other, and clears up some of the most doubtful mysteries in the practical solution of the question. It enables us to shorten our Carboniferous period some million of years, and give Nature the credit of a rapid worker and a wonderful chemist, instead of being slothful, mutable, complex, and *time-serving*.

ANTHRACITE COAL FORMATIONS.

Of the fact that our anthracite coal-fields are part of the great Appalachian coal formation there is no question; and that they were formed at the same time, and under nearly the same circumstances, is not doubted; but the cause which led to the subsequent change from bituminous to anthracite is a matter of some argument.

According to the topographical features of the present Alleghany coal-field and the dip of its strata, the anthracite fields are not conformable, and we have reason to believe that this non-conformity existed, though to a less extent, prior to the formation of coal. Had the same angle of dip prevailed which gives to the Alleghany field its basin shape, the elevation of the anthracite fields would have been considerably above the present elevation of the Alleghany Mountains. We have no doubt these fields were higher than they are now, but their immense deposits could only have been formed in corresponding basins, independent of the great or main basin; they never grew into their present magnitude on its mere edges.

The anthracite coal was, therefore, formed in deep, isolated lakes, whether in two or three can scarcely be determined, but all the area covered at present with conglomerate must have been under water at the commencement of the Carboniferous era, and probably much more that has since been denuded: therefore the presumption is they were originally of much greater extent than at present.

The folding of the strata in the vicinity of the anthracite coals—resulting, as before stated, from subsidence as a first cause, and lateral contraction as the last and second—naturally formed lakes or basins in this locality, as the same abrupt strata exist in the vicinity of the same line of volcanic vents, from one end of the coast range to the other.

Close proximity to the region of intense volcanic heat not only tended to keep the waters warm, but increased the vegetation and imparted to the elements great volumes of the vapors of carbon and its resulting gases, in connection with the hydrogen of water and the oxygen of the air.

We have noticed all our Palæozoic formations in the great Appalachian basins are decreasing from east to west, and that all our stratified rocks are much thicker on the Atlantic edge of the basin than in the interior. This law or condition also applies to the anthracite coal, which is nearly two-thirds thicker than the bituminous coals of the interior, or farther west. The cause undoubtedly had its existence in the same source which produced the superior thickness of the strata, viz. volcanic action, increasing both the heat and the volume of carbon.

We may apply the same theory of coal formation here which has been applied to the bituminous beds farther west, and find the conditions and coincidents to be still more favorable.

The deep-rooted Sigillaria, the towering Lepidodendron, and the gigantic Calamite, with their numerous species, have filled the deep lake to its brim, and a magnificent luxuriance of foliage spreads over its surface; carbonic acid shrouds the dark green in still deeper hues, and imparts to the growth a vigor unknown to later ages. Bitumen and carbon oils float through the mass, preserving it from decay and adding vast acquisitions to its bulk, until the face of the lake presents no appearance of water, but one vast sea of fronds and low leafy vegetation.

A shower of volcanic dust and ashes might crush the tender growth, and form a streak of slate or bone, and yet not sink the floating mass of vegetation. But ultimately its own weight would sink it to the bottom, and a new growth would arise, with but a slight interval, until even a "mammoth" of 60 feet thickness accumulated in its depths, with all the regularity of *bench*, and *bone*, and *slate*, or even parting sandstone.

Eventually these changes take place, as the result of subsidence or volcanic action, which stop the growth of the aqueous vegetation, and cover the mass hitherto formed with immense deposits of arenaceous and argillaceous sediment, drift, or volcanic eruptions.

The commotion causing those changes at length dies away, and quiet once more reigns. The finer particles of matter, held in solution by the waters, are thus precipitated, and form *fire-clay*, as the soil for another growth of Sigillaria; and thus the process goes on, and the coal-beds are formed.

Much has been said about the trunks of trees standing erect in coal-beds or in the coal measures, and many theories proposed to account for their existence. It seems natural that the towering vines and gigantic calamites should stand on massive and comparatively solid bases; and it would not be strange if those trunks should stand erect even when the foliage which they supported should be laid at their feet. Frequently, however, those massive forms are bent over and laid partially on their sides, with the stumps erect, and the top crushed between the strata. But the woody

part of these trunks lying outside of the coal-beds are always silicious or calcareous, and do not form coal. Nor do the trunks of arborescent trees, or the terrestrial vegetation, found in the surrounding strata, form coal, though drifted in profusion into the coal measures from the higher grounds surrounding the coal-basins.

There are local phenomena in the anthracite coal-fields which would require volumes to describe, and much more to explain. One of those is the varying thickness of the larger veins in the numerous small basins and in some portions of the large basins.

For instance, the lower veins in the shallow basins of New Boston, Black Creek, &c., are larger than the same veins in the deeper basins of Wyoming and Schuylkill, which would seem to imply that they were formed under different circumstances,—in less depth of water, or more uniform action of the conditions and causes operating in this production. But these details will be considered more minutely in the description of those basins respectively, further on.

The causes which lead to the production of anthracite within the recognized bounds of a great bituminous coal-field, cannot fail to be an interesting subject, though our conclusions may be dogmatic.

Compared with the immense extent of the field in which the anthracites exist, their area is insignificant, but their comparative value, under present circumstances, is in inverse proportion. As a pure coal, containing a maximum percentage of carbon, the Pennsylvania anthracites are superior to any mineral fuel in existence. A pure specimen contains 95 per cent. of carbon, and an average of the white-ash varieties will yield 90 per cent. It is, consequently, more dense and compact than any other kind of coal. A cubic yard will weigh about 2700 pounds.

One theory states that anthracite coal is a fresh-water formation, but does not specify the effects of fresh water in increasing the amount of carbon.

There is reason to credit the theory of fresh-water lakes, because there is evidence that our anthracite fields were detached formations, lower than the main Western basin, and, therefore, likely to contain fresh water; but the fact that the western ends of these lakes, or basins, contain semi-bituminous, and the eastern ends the purest of anthracites, seems to invalidate the theory in its application to the coal formation.

A second one is, that the bitumen has been driven from the coal by heat, the escape of the volatile matter being aided by the steep undulations of the strata and the frequent outcropping of the uptilted veins. This, of course, would be a sufficient reason, and would account fully for a dry, semi-bituminous coal. But it does not seem to meet all the conditions of a pure, hard anthracite. The fracture of all coals of a bituminous character is cubical, while the pure anthracite is conchoidal.

A coal once formed or created as bituminous will not lose its peculiar character, and no heat that can be applied will change its fracture without consuming it. We find a "*natural coke*" in the Richmond coal-field, and in other bituminous coal-fields, in the vicinity of *trap dikes*, where the bitumen has been expelled, leaving what should be anthracite according to the theory; but this coal has a cubical fracture and a dull, coke-looking appearance.

We have no doubt *heat* was the cause of dispelling the bitumen from our anthracite coals, but it was while the carbon was in a fluid state and *before the coal was formed*. The anthracite was formed in the earth as it now exists, and has not been materially altered by heat since its formation, though it has evidently changed its position, becoming more abrupt in its angles of dip by the continued subsidence or lateral contraction of the region.

We think the fact above set forth conclusive, and needs no demonstration, because the heat must have been greater at, or before, the time coal was formed, than since; and we need scarcely state that the volatile or bituminous matter would escape more readily when in a fluid than in a solid state; when unconfined rather than when sealed in the rocky strata of the earth.

We find the change from anthracite to bituminous gradual, and locally the point of change is imperceptible, while the gradation is general from east to west. In the vicinity of the volcanic regions, at the east, we have the pure anthracite; while at the western end of the same basin we find semi-bituminous, or soft anthracite. At Broad Top and in the Sullivan county detached basins—lying between the anthracite and the bituminous fields—the coal is in a transition state, containing from 80 to 85 per cent. of carbon, and, consequently, a very small amount of bitumen. At Blossburg, Ralston, and Cumberland we find a "steam coal" with an increasing amount of bitumen, or from 75 to 85 per cent. of carbon. Farther west, the amount of bitumen increases rapidly, ranging from 15 to 50 per cent. In the Kanawha region, in Kentucky and some portions of Ohio, the bitumen preponderates, while the carbon exists in minimum quantities. As a coal, the cannel contains the least, while the anthracite contains the largest amount of carbon.

The carbon forming anthracite came direct from its volcanic source, and was not affected by *carbonic acid* or *lime*, or by *hydrogen* to any great extent, as the coals of the West are. The gases or oils forming the bituminous coals must have been produced by internal heat, as in the case of anthracite; but these gases and oils arose through or from the great limestones and bituminous shales, and were, consequently, changed thereby.

We might extend this chapter to an indefinite length in explanation of those great chemical processes of Nature, and in giving many other theories of our coal formations; but, while aiming to be practical, we are in danger of giving more speculation and theory than fact.

In justice, however, to Prof. H. D. Rogers, whose eminent position and laborious researches among our coal-fields entitle his opinions to respect and regard, we give his theory of their formations, which will be found in the Appendix. It covers the ground of the terrestrial vegetation, peat-bog, and drift theories, or combines them all.

PART II.

CHAPTER V.

GENERAL DISTRIBUTION OF COAL.

Area of American Coal-Fields in the United States—Appalachian Coal-Basins—British North American Provinces—British Coal-Fields—European Coal-Fields—Comparative Table of the Coal-Producing Countries—Conditions necessary to the Existence of Coal —Formations of the Rocky Mountains—South American Coals—Coal-Fields of the Old World—The Ottoman Empire—Asia—Australia—Her Coal-Fields beneath the Conglomerate—Coal-Seams—Analysis.

In the present chapter we propose giving a brief account of the known or developed coal-fields of the world, reserving a detailed or general description of the more interesting and prominent coal regions for their appropriate place in the following chapters. In this we shall merely glance again at the extent of our coal-fields in comparison with those of other countries. We shall pass rapidly over the celebrated mining districts of Great Britain for the present, and dwell longer, perhaps, in the unexplored wilds of Australia and the coal-fields of China than in the valley of Wyoming or on the famous banks of the Tyne and the Tees. To the latter, however, we shall return again; but a brief notice of the former will be all we intend to give.

We may here notice a circumstance which may be perplexing to the general reader, and particularly to those who are familiar with the existing popular works on coal formations. No two works or authors agree on the general area of our prominent coal-fields or the coal area of our great coal-producing countries.

Taylor makes the coal area of Great Britain 11,859 square miles. Prof. Hitchcock gives it as 12,000. A popular little English work, "Our Coal and our Coal-Pits," gives the area on one page as 11,859, and on another at 7995 square miles; while Prof. Rogers states the area of the British coal-fields to be only 5400 square miles. We note this discrepancy to prepare the reader for such changes of figures and area as may appear in this work, since constant developments are being made which increase or decrease the estimates as careful surveys may determine.

In this country we find that new developments are constantly adding to our prospective coal area, while in England the contrary seems to be the

result. In 1845 our coal area was stated to be 133,000 square miles. It is now known to be over 200,000 square miles.

AREAS OF AMERICAN COAL-FIELDS.

		Sq. miles.
Massachusetts and Rhode Island, Anthracite, 100 to 600		300
Pennsylvania, Anthracite		470
Pennsylvania, Bituminous		12,656
Maryland,	"	550
West Virginia,	"	15,000
East Virginia,	"	225
North Carolina,	"	45
Tennessee,	"	3,700
Georgia,	"	170
Alabama,	"	4,300
Kentucky,	"	13,700
Ohio,	"	7,100
Indiana,	"	6,700
Illinois,	"	30,000
Michigan,	"	13,000
Iowa,	"	24,000
Missouri,	"	21,000
Nebraska,	"	4,000
Kansas,	"	12,000
Arkansas,	"	12,000
Indian Territory,	"	10,000
Texas,	"	3,000
Oregon,	"	500
" Anthracite		100
Washington Territory, estimated Bituminous		750
West of Rocky Mountains, "	"	5,000
		200,266

To which may be added, as recent formations:—

Tertiary Coals, Lignites, &c., mostly around the Rocky Mountains.. 200,000

AREAS OF THE GREAT COAL-FIELDS WITHIN THE ANCIENT APPALACHIAN BASIN.

	Sq. miles.	Length.	Max. bdth.
Alleghany, or Eastern Basin	55,000	875	180
Great Middle Basin	50,000	370	200
Northwestern Basin and Michigan	75,000	550	200
Western, or Rocky Mountain Basin	20,000(?)	400	50
Texas, or Southern Basin	3,000		
	203,000		

To this may be added the area of the British Provinces, as properly belonging to the same great formation.

COAL FORMATIONS OF THE BRITISH NORTH AMERICAN PROVINCES.

The total area of the Arcadian coal formation is not less than 9000 square miles; but only a small portion of it contains workable coal,—perhaps not more than 2200 square miles.

BRITISH NORTH AMERICAN PROVINCES.

	Sq. miles.
Newfoundland, estimated from 100 to 1000	250
Cape Breton, Sidney Coal	200
Pictou	350
Cumberland	250
Prince Edward's Island	150
New Brunswick	1,000
	2,200

AREA OF THE BRITISH COAL-FIELDS.

	Sq. miles.
Great Northern Coal-field, Northumberland and Durham	750
Great Central Coal-field, Yorkshire	900
Cumberland, West	100
Lancashire, Cheshire	500
North Wales	160
Shropshire	100
Staffordshire	250
Warwickshire	105
Forest of Dean	30
Somerset and Gloucester	50
Derbyshire	250
South Wales	1250
Scotland	1500
Ireland (estimated as 2227 square miles of formation)	250
	6195

If we deduct from the above 1000 square miles for faults, trap dikes, and "worked-out" territory, we may estimate the remainder, or about 5000 square miles, as the present available resources of the British coal mines.

The average thickness of the six principal English coal-fields is about 75 feet. Of this amount we may safely estimate two-thirds, or 50 feet, will be available, since the time will come when the seams which are now considered too small to "get" will be found workable. We know that seams of the more valuable coal, 12 inches thick, have been worked successfully, as we shall describe further on.

We may calculate the amount of available English coals on this estimate, and not be wide of the mark. Each foot vertical will yield 1500

tons of coal to the acre; or 50 feet total thickness will yield 75,000 tons per acre. Thus, 5000 square miles, at 640 acres to the mile, will produce 240,000,000,000 tons; but how much should be deducted for denudation and small extent of upper seams we cannot determine. We refer to the table on the next page.

AREA OF THE EUROPEAN COAL-FIELDS.

	Coal Formation.	Sq. miles workable coal area.
Great Britain	12,000	6195
France	4000	1000
Belgium	520	510
Saarbrook Coal-field	?	960
Westphalia	?	380
Bohemia	?	400
Saxony	?	30
Spain	4000	200
Russia	?	100
		9775

In the following table will be found a comparative estimate of the coal resources of the principal coal-producing countries. We have assumed that one-third of the total thickness of the coal-seams is available, and that each foot of coal in vertical thickness will produce 1500 tons of coal per acre, leaving 1613 tons as waste, which will cover the waste of the English miners, but will not cover the general waste.

THE CONDITIONS NECESSARY TO THE EXISTENCE OF COAL.

We will briefly notice here the undeveloped coal regions reported, and give such information regarding them as we may find available. Outside of the countries enumerated above, but little is known of the coal formations of the world, though it is probable that vast coal regions exist in Brazil, China, Hindostan, Africa, and Australia. We may state, however, positively, that no portion of the globe is so rich in coal as North America, or, more definitely, the United States. In no other instance do we find the Palæozoic strata so perfect and extensive, or which bear any comparison to the great Palæozoic coal formations of the ancient Appalachian basins.

The great Carboniferous era was a fixed period of time in the early geological history of the earth. It was the acme of vegetation, which owed its superior growth and magnificence to the favorable conditions that then existed; to the constant, unchanging tropical temperature, the genial moisture, and the superabundance of carbonic acid which then gave life and vigor to the ancient flora.

But, as we have pointed out in the foregoing chapter, it was not only

COMPARATIVE TABLE OF COAL-PRODUCING COUNTRIES.

(No allowance is here made for denudation, and the known contracted area of upper seams.)

Names of the Principal Coal-Producing Countries.	Total Area of Territory.	Area of Coal Formation.	Productive or Workable Coal Area.	Proportions.	Relative Area.	Thickness of Workable Coal.	Total Thickness of Coal.	Contents per Acre of each Country.	Number of Acres of Workable Coal Area.	Annual Productions of each Country.	Total Coal Resources or Estimated Supply, in Tons.
Russia in Europe..........	2,095,000		100	$\frac{1}{20000}$	1	......	......	....	....	....	....
Spain	177,781	4000	200	$\frac{1}{1000}$	2	......	......	....	....	....	....
Pennsylvania Anthracite.	46,000	500	470	$\frac{1}{100}$	5	60	90	90,000	800,800	10,000,000	27,072,000,000
Belgium	11,813	520	510	$\frac{1}{23}$	5	60	90	90,000	826,400	10,000,000	30,000,000,000
Austria........................	257,830	2000	800	$\frac{1}{322}$	8	60	90	90,000	512,000	5,000,000	46,080,000,000
France........................	203,736	2000	1000	$\frac{1}{240}$	10	60	90	90,000	640,000	10,000,000	57,690,000,000
*Great Britain...............	121,000	12,000	*6195	$\frac{1}{20}$	60	30	45	45,000	8,200,000	90,000,000	144,000,000,000
Arcadia	100,000	18,000	2200	$\frac{1}{45}$	22	20	30	30,000	1,408,000	500,000	42,240,000,000
†Pennsylvania	46,000	15,000	13,000	[illegible]	130	30	45	45,000	8,320,000	15,000,000	294,400,000,000
Illinois	55,405	40,000	30,000	[illegible]	300	20	30	30,000	19,200,000	1,000,000	576,000,000,000
Australia	3,120,000	100,000	15,000	$\frac{1}{200}$	150	20	30	30,000	9,600,000	250,000	288,000,000,000
United States................	3,000,000	500,000	200,000	$\frac{1}{15}$	2000	20	30	30,000	128,000,000	22,000,000	3,740,000,000,000

* Assuming only 5000 square miles of the British coal-fields to be now available.

† In the present production of Pennsylvania we include its Western bituminous trade of about five million tons. We estimate the entire bituminous trade of the West at 10,000,000 tons, which swells the production of the United States to 22,000,000. See Chapter XIX.

necessary that the atmospheric conditions should be thus favorable, but the physical condition was of equal importance. Water in shallow seas or lakes, a soft and yielding soil, and a general basin-shape were all prime necessities; and such are the conditions required to produce coal, according to the former vegetation theory.

But if we have clearly expressed the nature and requirements of coal formations in the preceding chapters, it will appear evident that the above conditions are not of themselves sufficient to produce the mineral coal of our true Carboniferous era; and consequently the coals of that era are confined to certain lithological strata, generally represented by the great Carboniferous limestone and the millstone grit, on which the true coals are invariably found, except in cases of denudation or subsidence. The exceptions to this general law of nature are but few; in fact, no great and extensive beds of true coal are found in any other connection. The Carboniferous era closed the Palæozoic day, and crowned the Palæozoic column.

The simple reason is, certain combinations are required—heat, moisture, carbonic acid—to produce vegetation; a lithological structure necessary to retain water in basins; internal heat operating on limestones, or carbonated rocks, to produce, in connection with water, the hydro-carbons or bitumen of our coal formations.

When coal is found under other circumstances, it is always imperfect, unreliable, and limited, deriving its carbon oils or bitumen direct from volcanic sources, or, to a limited extent, from the same causes operating to form the true coal, as the Permian coal immediately above the Carboniferous has been formed.

We have thus stated briefly the reasons why coal may not be found in all countries, since the Carboniferous era existed through a comparative lengthy period of time, and seems to have flourished cotemporaneously in all parts of the earth; and we might expect to find the conditions, as set forth in the two first propositions, viz.: vegetation and basins of water in many portions of the world where coal *does not exist*. We therefore cannot expect to find extensive fields of coal, or any true coal of the Carboniferous period, where all the before-mentioned conditions do not exist.

We do not expect to find great deposits of the true coal west of the Rocky Mountains, in Mexico, Central America, or the mountainous regions of the Southern Continent, or even north of the great lakes. But coal may, and does, exist in all the regions named, as it exists in the same character of rocks, and, perhaps, under the same conditions of formation in small basins of imperfect form along the granitic slopes of the Atlantic, in Massachusetts, Rhode Island, Virginia, and North Carolina; or still more recent and more imperfect deposits of Tertiary coal and lignites may exist in extensive fields, as those which occupy so large an area around the Rocky Mountains.

COAL FORMATIONS OF THE ROCKY MOUNTAINS.

We include under this head an extensive and rather indefinite region, extending from British America to Mexico.

This portion of our continent is a *terra incognita*, in a comparative sense, to the geologist; but the Palæozoic formations are known to exist around those towering peaks of granite to an indefinite extent, either concealed by the cretaceous and recent deposits, or in the obscurity of savage wilds. Many of our intrepid explorers of the West, however, have reported coal along the base of the Rocky Mountains, and numerous localities are pointed out, from the Black Hills in the North, across the Platte and Arkansas Rivers, to the Rio Grande, where true coal has been found.

Mr. Elisha Beadle, a miner of much experience from Pottsville, Pennsylvania, mentions the existence of true coal in the Black Hills, near Fort Laramie, in a letter published in 1853.

He says "the coal exists in regularly stratified sandstones, while the appearance of the formation is much the same as that in Schuylkill county and in the bituminous fields of the West."

From a careful comparison of the various descriptions we have received of the coal formations lying along the eastern base of the Rocky Mountains, we are constrained to conclude them to be bituminous coals, but of an indefinite era. Whether they are a continuation of the great Appalachian formations or not, it is impossible at present to determine.

There appears to be an immense formation of brown coal, Tertiary coal, or lignite, lying between the known and developed portions of the true Carboniferous coal and the coal of the Rocky Mountains. Its range is immense, stretching from the Rio Grande to the head-waters of the Missouri, possibly extending to the limits of the Palæozoic formations in British America to the north, and extending along the eastern slopes of the Rocky Mountains, the Mexican Cordilleras, and the Andes of the South. It is, therefore, possible and probable that our true coal formation of the East continues its depreciation, as we have frequently noticed, until it terminates in mere lignites, and the true coal formations of the West may be independent basins of recent formation. The fact of these immense deposits of Tertiary coal or lignites existing in the western portions of the great basin, would indicate the absence of the necessary conditions required for the formation of true coal; and the thinning or depreciation of the Palæozoic strata in that direction would justify such a conclusion, though ample evidence is offered of the existence of a shallow sea.

There is, however, a second theory which applies to the Western formations, but based on mere speculation in the absence of geological knowledge. This theory assumes that the true or carboniferous strata may underlie the Western fields of brown coal and lignites and the cretaceous

strata of the prairies of the far West, as the true coals of Illinois underlie the Permian strata. This is doubtful, to say the least, though we intimated in a former chapter the possibility of the formation of the palæozoic strata in a western as well as an eastern direction.

The true coal of the great basin extends through Texas in a southern direction, and run to a point or comparatively narrow deposit in Mexico. It is found in Coahuila, New Leon, San Luis Potosi, and as far south as Vera Cruz and Oaxaca. It has been mined at Reveilla, on the left bank of the Salada River, about 125 miles above Camargo, by an American company. The coal is hard, bituminous, and stratified with sandstones. It has also been proved in Oaxaca and on the proposed route of the Tehuantepec Railroad.

It would appear from the foregoing facts that the ancient Appalachian Sea was not confined to the present North American Continent, but that its southwestern borders were along the eastern slopes of the mountains of Mexico and Yucatan.

We may, therefore, assume that the ancient sea was isolated,—that it had no connection originally with the Atlantic, but has been subsequently connected by the subsidence of the ancient coast-ranges to the south.

This interesting scientific question cannot be determined without more geological knowledge than we now possess of the western and southern limits of the great basin.

SOUTH AMERICAN COALS.

Coal exists at various localities along the Pacific coast, from Russian America to Patagonia, and is now mined to a limited extent in Vancouver's Island, Washington Territory, Oregon, California, at Panama, in New Granada, and at the towns of Lota, Lotilla, and Coronel, in Chili. But all these coals are of later date than the true Carboniferous, and appear to be the production of periods from the Jurassic to the Tertiary. They are of all grades of the bituminous class, from the mineral pitch, or asphaltum, to the natural coke. The veins or seams are generally thin and unreliable, and subject to the imperfections natural to all coals of recent formations. But, under present circumstances, these deposits of coal are invaluable to the commerce of the Pacific.

The coal-mines of Panama are worked by several English and American companies almost exclusively for the use of the ocean-steamers of the Pacific. The coal is of a soft, bituminous character, and is much inferior to the English and our Cumberland steam coals.

Though coal exists at intervals along the entire Pacific coast, it is only worked at two prominent points south of California, viz.: Panama and at the Chilian mines in the northern portion of Araucania. The mines in

Chili are located at the towns or bays of Lota, Lotilla, and Coronel, which lie about 200 miles north of Valdivia. The coal area is comparatively extensive, but the seams are generally thin and frequently terminate abruptly. Their dip is irregular or undulating, and mining operations are conducted by both shaft and drift. A considerable coal trade is done here, and sailing-vessels are constantly being laden for various ports on the Pacific, and passing steamers generally supply themselves here. The coal is soft, and burns rapidly with great flame and smoke, but leaves only a moderate residuum and makes no clinker. This coal costs about six dollars per ton on board; while anthracite is now (1865) worth twenty dollars per ton in this part of the world.

The mines of Lota are the most extensive, and produce about 10,000 tons per month under the management of experienced English miners. This is exclusive of the production of the Lotilla and Coronel mines, of which we have no data.

Of the coal of Brazil and the Atlantic slopes of South America but little is known, though it is said to exist in numerous localities, and the configuration of the interior basins would lead us to expect the existence of coal if the geological conditions are favorable.

We may anticipate many valuable results from the present scientific expedition of Prof. Agassiz and his party to South America. They visited the rich and magnificent region of the Amazon, equal, perhaps, to the great valley of the Mississippi, but which has hitherto been as a sealed book to science and the world.

EUROPE.

In an accompanying table, on page 86, we gave the coal area of the principal coal-producing countries of Europe, and shall not, in this chapter, attempt a description of their old and celebrated mines; but we propose to devote the following chapters to that purpose. We may here notice, however, the exceedingly limited area of the European coal-fields in comparison with those of the United States. The whole of Europe, comprising a total area of 3,758,000 square miles, has less than 10,000 square miles of coal-producing area; while the United States, with 3,000,000 square miles of territory, has over 200,000 square miles of productive coal area. Yet, limited as the coal area of Europe is, the islands of Great Britain, with a total territory of 121,000 square miles, contain more than half the coals of Europe. The proportion of coal in Europe is about one square mile of coal to every 375 of territory; while the proportion of England is $\frac{1}{20}$, or one square mile of coal to every 20 square miles of territory. The proportion of the United States is $\frac{1}{15}$, or one of coal to every 15 of territory.

THE OTTOMAN EMPIRE.

The coal of Turkey is principally in Asia Minor, but partly in Europe, and lies along the shores of Marmora and the Black Sea, and is distributed over a range of 180 miles along these seas and the Archipelago.

FIG. 9.

TURKISH COAL FORMATION.

It appears to have a wide distribution in this part of the Turkish Empire. The localities where it is found are at Amastra and Erekli, on the Black Sea, Vivan, on the Sea of Marmora, Scala Nova, on the Archipelago, about forty miles from Smyrna, and Rodosto, in Roumelia.

The constituents of this coal, as analyzed by Prof. Hitchcock and others, are:—

	Black Sea.	Marmora.	Roumelia.
Gaseous matter	31.80	52.00	48.00
Fixed carbon	62.40	40.50	47.00
Ashes	5.80	7.50	5.00

The coal of the Black Sea appears to belong to the true coal formation of the Carboniferous era. It rests on the millstone grit, which is supported by the limestone. The coal of Roumelia and Marmora, however, has been pronounced inferior, and either belong to a later formation or exist on the outskirts of the true coals. The region is much disturbed and irregular; the dip—varying from 20° to perpendicular—is sometimes even inverted and crushed,—the effects of crust-movements subsequent to the coal formation.

The coal of Erekli and vicinity, on the Black Sea, is mined to a considerable extent under English management. Some five or six seams of coal have been developed, ranging from five to twelve feet thick; but others are known to exist, and one twenty feet thick has been discovered. These mines—the Cosloo mines, near Erekli—produced in 1854 about 20,000 tons per annum, principally for the use of the combined English and French fleets then operating in the Black Sea. Preparations were

being made to produce 100,000 tons per annum. The cost was estimated at about six dollars per ton on board.

There is a singular circumstance existing in connection with the coals of Alijasah,—about eight miles from Erekli,—where several seams, from four to five feet thick, exist. The rocks in the vicinity of these seams are disrupted or broken, and large fissures are filled with asphaltum, or bituminous coal, apparently of a later date than the coals with which it is found, the result, undoubtedly, of the subterranean carbon oils becoming solidified in those cracks.

Specimens of twenty varieties of Turkish coal were received at the Great English Exhibition. Some of these came from other localities than those named, and among others we may mention Moldavia, Monastir, Mount Lebanon, and Tripoli.

ASIA.

There are but few other localities of which we have available data, where coal has been developed.

We only know that extensive fields of the true Carboniferous formations, both bituminous and anthracite, exist in the vast Chinese Empire, which contains 5,000,000 square miles of territory.

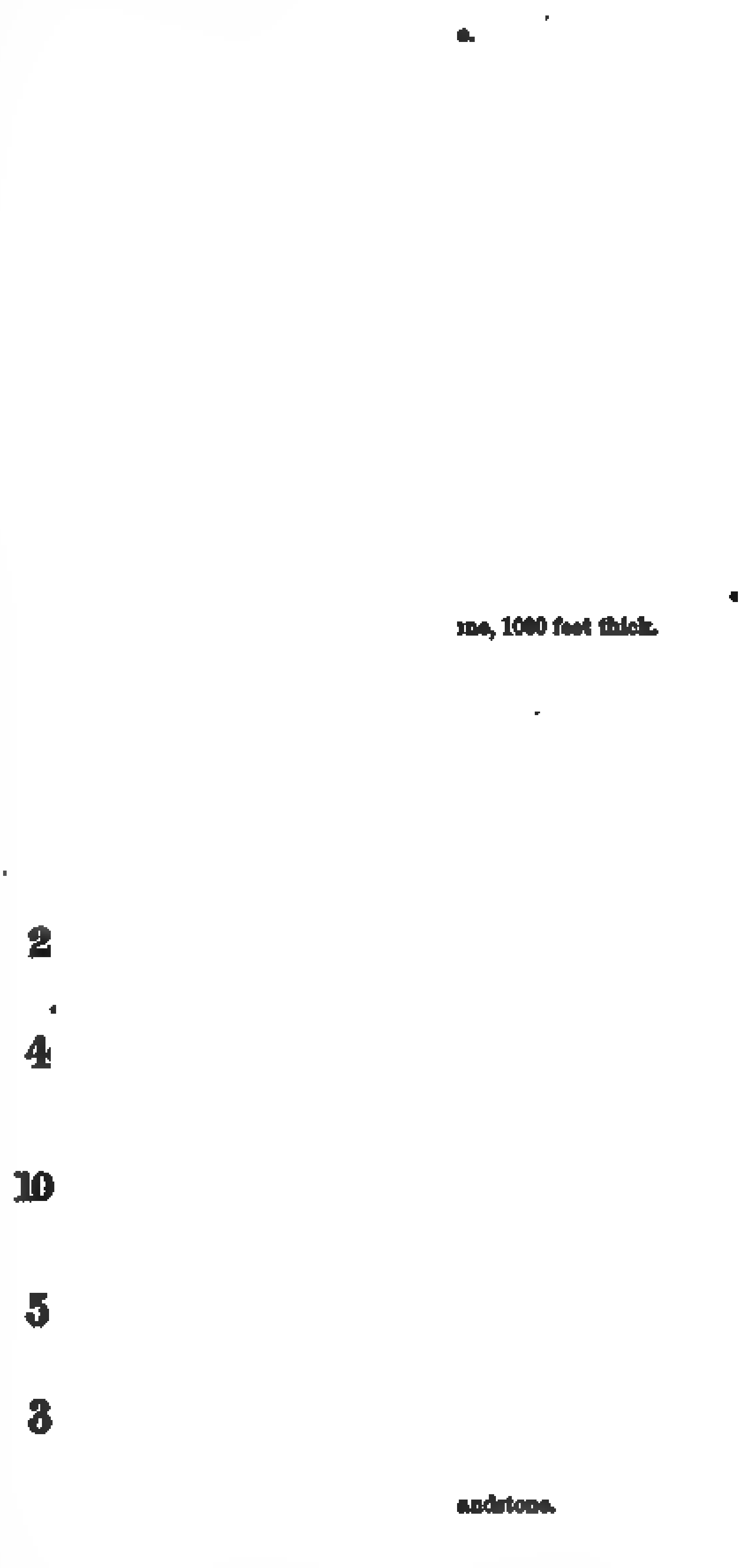
Mining is conducted in a primitive manner, as it was originally in England, or as late as 1840–1850 in some portions of that island, but in a more Christian and civilized manner. In England, Scotland, and Wales, *women* and *girls* were employed to transport the coals to the surface; but in China only men and boys are employed in this operation, which, however slow and behind the age, is rather in advance of that civilized people, who, about the same time, forced opium upon the Celestials at the point of the bayonet.

The English nation, however, has nobly atoned for some of its past errors, and has sent civilization, liberty, and light to the uttermost corners of the earth: if sometimes at the cannon's mouth or the point of the bayonet, it is none the less to be valued and appreciated. The exclusive and semi-barbarous Celestials, with their genealogy almost direct from Noah, and their population of 400,000,000, are less powerful than the English in physical force or material resources, and utterly in the dark in regard to science and the arts. We may attribute this wonderful ascendency and increase of wealth and material power, first, to the enlightening and civilizing influence of religion, and secondly, to the consequent intelligence which has developed her resources of coal and iron.

Coal is known to exist in Hindostan, on the Ganges, and is mined to some extent by the British in India; but too little has been developed to enable us to make our data interesting or valuable. We merely glance at those distant localities to give a general view of the distribution of coal;

and we may here simply mention the fact of the existence of coal in Africa being reported by Livingstone and other explorers of the interior of that vast and undeveloped continent. But the geology of that country, as far as we are yet informed, is not favorable to the existence of coal. It is found at the mouth of the Zambezi, and at numerous points on the extensive African coasts; but we believe it is nowhere mined to any extent.

FIG. 10.



AUSTRALIAN COAL FORMATION.

THE COALS OF AUSTRALIA.

The coal formations of Australia are as peculiar as most of its productions. It will be noticed that the coal-seams are beneath the conglomerate, instead of above it, and that the heavy sandstones corresponding with the "old red" are the superior instead of the inferior strata. The fossiliferous sandstone, upon which the coal formations rest, appears to be of the Devonian system; but there is still a great diversity of opinion in regard to the age of the Australian coal. Several eminent geologists place it among the subcarboniferous rocks, or false measures, beneath our true coal formation. Others place it in the Permian formation, or above the true coal measures; while many practical men are inclined to place it among the productions of the Carboniferous era. But it is evident, from the thin and rather uncertain character of the seams, and their position below the conglomerates and heavy sandstones, that the coal of the New South Wales formation belongs to the lower coal series of the English, or our proto-carboniferous era.

The Carboniferous limestone has been discovered some distance in the interior, but its position in relation to the coal had nót been determined. There is some probability that it is synonymous with the conglomerate, which exists above the coal, since this rock is made up of fragments, and is much the same as our conglomerate where it commences its metamorphism into lime.

Immediately over the "Sidney Sandstone"—which is from 1000 to 1400 feet thick—an immense deposit of slates and shales, intercalated with thin coal-bands, is found in all the basins or depressions of the great sandstone. This may be the true coal formation; but Nature, having exhausted her stores of carbon at an earlier period, produces but barren measures now.

The existence of coal in the upper measures is doubtful though the developments are but limited. What may yet be found in the interior of this vast continent—island we can scarcely call an area of 3,120,000 square miles—it is impossible to say.

But the fact that this coal formation—always beneath the Sidney sandstone*—is found extensively over a great portion of Australia, leads us to conclude it to be the chief coal formation of that country. If the coal existed above the sandstone in any valuable quantity, it would have been discovered at some of the many localities where the lower formation is developed.

The coal area of New South Wales, or that portion of it near Sidney, on the Hunter River, and Woolongong, on the Nepean River, is computed at 15,000 to 16,000 square miles. But this coal, accompanied by the great Sidney sandstone, is also found at Victoria, in Western Australia, Kerguelen's Land, New Zealand, and Van Diemen's Land, or Tasmania. It has been found at many points over this wide range of territory,—in fact, so general and extensive that the coal area of Australia may yet vie with the wide fields of the United States. Of its great extent there can be no doubt; but of its comparative commercial value there is less certainty.

It will be noticed by the analysis and measures given further on, that this coal is by no means valueless or unavailable. The seams are much mixed with slate and dividing bands, but the coal is generally good and serviceable, and of immense value to the steam navigation and commerce of that remote quarter of the globe.

A vast mountain-chain bounds the eastern coast of Australia, some 20 to 30 miles inland, but is prominent from Tasmania to North Australia, in a general north-and-south direction. It is known as the Blue Mountains.

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* Dana states this rock to be soft and friable, and composed of fine grains of quartz, feldspar, and mica, the quartz predominating; colors of the layers, white, grayish, and yellow, like ordinary sand. Iron ores in the form of sand and thin layers are common to this rock, and when exposed to the atmosphere soon stain or redden the surface.

Its crest or axis is of granite, and is flanked by gneiss, or metamorphic rocks, pierced by syenite, greenstone, basalt, trap, &c.

At some low points the superincumbent Sidney sandstone overlaps both the gneiss and granite rocks, apparently in the ancient basins, and now forms vast plateaus or basins of coal formation; but generally the coal lies on the sea-face or Pacific slopes of the mountain-range. To the west of this range, behind Sidney, are the famous gold-regions of Australia; and there we would not expect to find coal. We presume, therefore, the coals of the east are chiefly confined to this slope. In Western and Middle Australia both the physical and lithological conformations may be different.

In the vicinity of Sidney the *strike* is northeast and southwest, and the coal generally exists in long trough-like synclinals, bounded by sharp parallel anticlinals; but the dip is by no means uniform: it ranges from one to thirty degrees, and leans to every point in the compass.

Between Newcastle and Woolongong (on the Hunter and Nepean Rivers, south of Sidney) the basin is nearly 150 miles wide, in a right angle or transverse direction to the strike. Its extreme depth is calculated at 5000 feet, and its average dip one degree; but the undulations are such that abrupt dips are frequently met with, and numerous trap dikes, or veins of porphyries, greenstone, and basalt, burst through the formation. Those frequent volcanic interruptions are "troubles" to the miners, and greatly impair the value and productiveness of the coal-field. In the vicinity of those dikes the coal is considerably altered, and is frequently changed to a coke.

COAL-SEAMS.

We give below several sections of coal-seams as worked in the vicinity of Newcastle. There seem to be no identifying features, as the coal and bands are subject to frequent changes.

COALS OF AUSTRALIA.

Section of Coal-Seam No. 1.

	Feet.	Inches.
Top coal, bright	0	6
Band, clay	0	0½
Black slate	0	4
Cannel coal, coarse	2	6
	3	4½

Bottom or Yard Seam No. 5.

	Feet.	Inches.
Top coal, good	0	4
Band, black metal	0	4

	Feet.	Inches.
Coal, good	1	1
Band, black metal	0	1
Coal, good	1	3½
	3	1½

Coal-Seam No. 2.

	Feet.	Inches.
Good coal	2	6
Coal and slate	0	3
Good, bright coal	0	2½
Metal band	0	7
Good, bright coal	0	7
	4	1½

Dirty Seam No. 4.

	Feet.	Inches.
Top coal, not worked	1	6
Good coal	0	6
Band, gray metal	0	2
Good coal	0	10
Fire-clay	0	6
Good coal	0	4
Band, black clay	0	8
Good coal	1	6
	5	6

Coal-Seam No. 3.

	Feet.	Inches.
Coal, good	2	2
Slate and coal	2	0
Good coal	1	3
Blue slate and coal	1	0
Good coal	2	10
	9	3

Coal-Seam No. 4.

		Feet.	Inches.
	Roof, mixed metal	1	7
Not worked	Coarse coal	0	6
Not worked	Band	0	5
Not worked	Coarse, splinty coal	2	2½
Not worked	Band	0	1
		4	9½
	Good coal	3	7
	Clay band	0	2
	Good coal	1	2
		8	1½

Burwood Seam No. 3.

	Feet.	Inches.
Top coal, not worked	3	0
Fire-clay, not worked	2	2
	5	2
Good coal	2	1½
Fire-clay band	0	2½
Good coal	0	4½
Band	0	2½
Good coal	2	4
	10	5

Dip, 4° west.

ANALYSIS OF COALS.

	Coke.	Gas.	Ash.	Sulphur.
Seam No. 1	69.10	30.90	5.64	7.13
Seam No. 2	64.88	36.22	6.52	7.60
Seam No. 3	67.60	32.40	4.16	7.03
Seam No. 4	71.90	28.10	4.00	7.20
Seam No. 5	75.50	24.50	6.60	7.21

As there is some doubt as to the correctness of the above analysis, in regard to the quantity of sulphur, we give the analysis in a different form, as made in England. Carbon 82.39, hydrogen 5.32, nitrogen 1.23, sulphur 1.70, oxygen 8.32, ash 2.04.

The amount of coal mined in the vicinity of Newcastle during 1857 is reported at 250,000 tons.

There are many interesting facts connected with the geology of Australia, with which we might extend this chapter; but, having devoted considerable space to its coal formations, we must be content with a few closing remarks, and dismiss for the present, or perhaps altogether, those distant and misty panoramic scenes which we have been so rapidly reviewing.

A COMPARISON.

At the first glance, we are disposed to consider the coals of Australia but thin and poor in comparison with the coal formations of the true, or Carboniferous, era; but, on closer inspection, we find them by no means contemptible or insignificant when placed side by side with the true bituminous coals of England or our Western coal-fields. Our large anthracite veins are an exception, and are superior to all others.

There are more seams in the true coal measures, but their average thickness is not greater than the Australian, and we may perhaps be safe in stating the thickness of intervening or intercalated slates and bands to be

but little in excess in proportion to the amount of coal. We refer the reader to the description of the English coal-fields in the following chapters.

The value of the Australian coals does not, however, depend entirely on their thickness or the economy with which they can be mined. It is the locality and remoteness from all sources of supply which increases their value, since they are comparatively pure and serviceable. If they cost one or two shillings per ton more at the pit's mouth than the English coals, that additional cost is trifling when compared with the transportation of fuel from Newcastle-upon-Tyne, a distance of 13,000 miles.

It would be as much as an ordinary steamship could do to carry her coals without other freight for a trip from London to Australia and back, but the existence of available coal at both places alters the case very much. In this view, and in consideration of the increasing demands for fuel in that vast, remote, and strange country, the existence of coal is really a providence.

NOTE.—Most of the facts in relation to the Australian coal-fields were obtained from an admirable paper on the subject, by Mr. Henry T. Plews, published in the "Transactions of the North of England Institute of Mining Engineers," vol. vi. 1857–58.

CHAPTER VI.

THE HISTORY OF COAL AND ITS DEVELOPMENT.

The Earliest Notice of Coal in the Year 371 B.C.—Coal used by the Early Britons and Romans—Fossil Fuel used in England 852 A.D.—Coal sent to London in 1240—First taxed in 1379—Iron first made with Pit-Coal in 1612—Coke came into General Use in 1740—Progress of the Coal-Trade—Production—Capital, Value, and Labor—Progress of Invention and Improvement—Locomotive—Davy Lamp—Mining—Ventilation—Miners—Hot Blast—Cost of Iron—Coke—Iron—Steam-Power in England—Pennsylvania Anthracite—Wyoming Valley—First used by Blacksmiths—First used in Grates—Opening of Trade of Wyoming—Avenues—Shipments—The Lehigh Region—Discovery of Coal—The Lehigh Coal-Mine Company—Stone-Coal—First sent to Philadelphia—First Successful Introduction as a Fuel—Great Coal-Quarry—First Railroad—Schuylkill Region—Nicho Allen—Col. George Shoemaker—White & Hazzard—"Let it Alone"—Opening of the Coal-Trade on the Schuylkill—Development of the Mines—The Middle Coal-Field—Cumberland—Western Coals.

DEVELOPMENT OF COAL IN ENGLAND.

WE propose in the present chapter to present a brief sketch of the history and development of coal, confining ourselves almost exclusively to the older coal-fields of England, and to the early history of our Pennsylvania anthracite regions: the first presenting the earliest data and the greatest present magnitude; the second presenting to us the most interesting features and promising the greatest future importance.

In the early periods of civilization, before men congregated in cities and towns, the products of the forest were sufficient for their wants; but, with the progress of Christianity and the consequent development of intelligence, men became more sociable and dependent on each other, and not only found pleasure and profit in the social intercourse and the exchange of ideas, but also in the exchange of labor and the productions of labor. This led to the happy results of the present day, when the arts and sciences are made practically useful to man and the hidden resources of Nature made available by their means. Thus, *coal*, *iron*, and *oil* are the developments of modern times, and are more the result of *true* intelligence than *prime* necessity. Men lived in cities and masses long ago, as they now live in China, yet did not, and do not, avail themselves of those great elements of strength and power,—not because they were not wanted, but because their intellectual attainments could not appreciate the bounteous gifts of Nature or convert them to use.

Coal exists in Syria, on Mount Lebanon, and may have been worked

during the early ages, as we find frequent allusions to "coals of fire" in the Scriptures, which, however, may as likely refer to charcoal as stone-coal.

The earliest notice we find of *stone-coal* is B.C. 371, in which Theophrastus, a Greek author, speaks of *Lithanthrax* as being found at Ellis and used by the smiths at that time.

But the coal-fields of England were undoubtedly the first to be practically developed. Evidences are found which demonstrate its use by the ancient Britons prior to the Roman invasion; and the discovery of tools and *coal-cinders* near the stations on the Roman wall proves that it was used by them.

The first record which has come to light of the use of *stone-coal* in England, mentions the receipt of twelve cart-loads of fossil fuel, or pit-coal, by the Abbey of Petersboro, A.D. 852. But not until 1180 do we find any records of regular mining. At this date, however, several leases or grants are recorded, in the books of the Bishop of Durham, of mines in the county of Durham. In 1240 coal was first sent to London, and in 1300 considerable quantities were used by smiths, brewers, and others.

In 1379 the first government tax was laid on coal; and from that time until the eighteenth century, or 1831, the tax was frequently changed, the lowest named being a duty of one shilling per chaldron, and the highest ten shillings per chaldron on all coals sent beyond sea.

In 1831, after a continuation of 400 years, the tax was repealed. The highest home-tax, perhaps, was during the great French wars, when it was nine shillings and fourpence per chaldron.

In 1612 the first patent for making iron with pit-coal was granted to Simon Sturtevant, at which time it was claimed that about three tons per furnace per week could be made with coal; but it does not appear that Sturtevant met with any success. Dudley again made the attempt, and obtained patents in 1619 for the manufacture of iron with *pit-coal* in Worcestershire. But poor Dudley lost all his property and was imprisoned for debt in his endeavors to perfect a process which has since been made so successful.

We do not read of any further attempts at the manufacture of pig-iron in the blast-furnace with pit-coal until 1713, when a Mr. Darby, of Colebrook Dale, appears to have used it successfully. In 1747 we learn that cast iron, suitable for the manufacture of cannon, was made with pit-coal, and that both coal and iron were brought out of the same mine.

In 1700 the number of blast-furnaces in England appears to have been about sixty-four, using charcoal as a fuel, and were, consequently, located more with reference to a supply of wood than any other consideration. Sussex had the greatest number; there were some in Kent, and a few in the midland counties and along the Welsh borders. But about 1740, when

the change of fuel from charcoal to coke took place and was being brought about, the number of furnaces decreased to 59, and the manufacturing interests were gradually removed from the woodland to the coal districts. The annual product of iron, about this time, decreased more than one-fourth, and was only 17,350 tons; but as the use of coke became general and better understood, the trade again increased to 61,300 tons in 1788, of which only 13,000 tons were made with charcoal, and from that date the development of the iron-trade of England was rapid, as the following figures indicate.

PROGRESS OF THE IRON TRADE OF ENGLAND.

		Tons.
*1796, 121 blast (coke) furnaces produced		124,793
*1802, 163 coke furnaces produced		170,000
*1806, 227 (only 159 in blast)	"	250,000
*1820	"	400,000
*1827, 280 furnaces in blast	"	654,000
1845		1,250,000
1851		2,500,000
1864		5,000,000

PROGRESS OF THE COAL-TRADE OF ENGLAND.

The records of the coal-production of Great Britain were neglected during its early development, and cannot be traced back with any accuracy beyond the year 1828.

We give the coastwise and foreign vend or shipments from Newcastle, as indicating the average increase in the British production.

SHIPMENTS OF NEWCASTLE COAL.

	Coastwise.	Foreign.	Total tons.
1602			190,000
1609	214,305	24,956	239,261
1622	301,785	43,755	345,540
1630	253,380	36,542	289,922

Newcastle and Sunderland.

1660	537,000
1700	653,000
1710	650,000
1750	1,193,457
1800	2,520,075
1820	3,403,225
1840	5,587,384
1861	10,364,647

* Dr. Ure.

During 1861 the total production of Durham and Northumberland, or the Great Northern coal-field, was 21,777,570 tons, of which amount 2,700,000 tons were consumed at home or wasted at the mines in fine, &c.

TOTAL PRODUCTION OF GREAT BRITAIN.

			Total tons.
1845			31,500,000
1850			50,000,000
1855			65,000,000
1860	England	63,870,123	
"	Wales	8,561,021	
"	Scotland	11,081,000	
"	Ireland	123,070	83,635,214
1864* (of which about 86,000,000 were vended)			90,000,000

STATISTICAL TABLE OF THE CAPITAL, LABOR, VALUE, AND PRODUCTIONS OF THE ENGLISH COAL-TRADE, 1854.

Names of Districts.	Number of Men and Boys employed in the Mines.	Amount of Capital employed in Mining.	Yearly Production of each District, in Tons.	Value of Coal at the Pits.
Durham and Northumberland..	Under ground, 29,000 Above ground, 7,624	....	....	....
	36,624	$65,000,000	15,500,000	$30,000,000
Cumberland	....	....	887,000	....
Yorkshire	....	....	7,260,000	....
Derbyshire	....	....	2,466,696	....
Nottinghamshire	....	....	813,474	....
Warwickshire	....	....	255,000	....
Leicestershire	....	....	439,000	....
Worcestershire	†36,624	....	3,750,000	....
		$50,000,000	15,811,670	$22,000,000
Staffordshire	....	....	3,750,000	....
Lancashire	....	....	9,080,500	....
Cheshire	....	....	786,500	....
Shropshire	....	....	1,080,000	....
Gloucester, S. and Devon	†36,624	....	1,492,366	....
		$50,000,000	16,389,310	$23,000,000
Flintshire and Anglesea	....	....	1,143,000	....
Monmouthshire, Glamorganshire, and Pembrokeshire	....	....	8,500,000	....
Scotland	....	....	7,448,000	....
Ireland	†36,624	....	148,750	....
		$55,000,000	17,239,750	$25,000,000
	146,496	$220,000,000	64,789,789	$100,000,000

* The production of the British mines, including colliery and home consumption, is not less than 100,000,000.

† The number of hands is estimated for the last three districts. The figures are from Hunt's Statistics.

PROGRESS OF INVENTION AND DEVELOPMENT.

Previous to 1660 the transportation or conveyance of coal, both above and below ground, was done by hand or by horse-power, and for a long subsequent period much of the conveyance was done in the same manner. Women and girls generally conveyed the coals to the surface, and horses, mules, or asses carried them to the consumers in sacks, and still more subsequently in carts. But during 1660 wooden rails and trams were first used above ground at the mines, and about the same time the steel-mill was introduced for the purpose of lighting gaseous mines.

Rails were not used under ground until about 1777, when they first commenced to take the place of sledges or "coaves," which, however, they have not yet entirely displaced in this country, since the sledges or coaves were much in use in the South as late as 1860. In 1790, cast rails were first used, and wrought-iron rails in 1815; from this date improvements made rapid progress.

Coal gas was made use of practically, in England, for light in 1798 or 1800. Steamboats were first introduced there in 1812, though in use in America since 1790, when Fitch made his first trip on the Delaware.

Steam-power appears to have been used to a limited extent at collieries in 1714, but was not generally or perhaps much in use until 1800. The first locomotive was made by Trevithick and Vivian, who were Cornishmen, in 1804, and was used on Merthyr Tydvil Railroad in South Wales.

Stephenson's first improved locomotive was put in use in 1814, but was not used on public railways until 1825, when the Stockton & Darlington line was opened. The Stephenson and Davy safety-lamps, for use in fiery or gaseous mines, were invented or perfected for use in 1815; and from this date the development or increase of the English coal-trade has been very great.

The improvement in mining and ventilation has also kept pace with the invention and demands of the times. Formerly, coal was dug in open pits along the outcrops of the seams. Deeper pits were subsequently sunk to water-level, or drifts were driven horizontally on the coal, and the coal conveyed to the surface on the backs of women or girls; but no system or order of mining or ventilation was pursued. We presume the mode generally pursued in the Southern States to be a pretty correct model of the old English, since both were conducted on primitive principles.

On the introduction of steam machinery and the consequent opening of deeper and comparatively extensive mines, improvements became necessary, and the "pillar and stall" and a system of natural ventilation was first adopted. This mode is, or was, much the same as that now in use at the anthracite mines of Pennsylvania. But by this mode of mining from one-fourth to one-third of the coal was lost, from the inability to secure the

coal in the pillars by "robbing," in consequence of the crushing weight of the top causing an abandonment of the "face," or by the "creeping" of the bottom preventing access.

It may be difficult to devise a better system of mining for the steep veins of the anthracite regions, though the present mode is susceptible of much improvement. But in the flat seams or low basins of England there were both the means and the want of improvement. The mines were deep and gaseous, and the seams generally thin and comparatively unproductive:

FIG. 11.

MINER AT WORK.

therefore an improved system of ventilation was demanded, and it became a matter of importance in the economy of mining to produce as much coal as possible from a given area.

In this connection we cannot give a detailed description of the various modes of mining and ventilating as adopted at different times in the English mines, from the "pillar and stall" and the "board and pillar" to the "board and wall," or the "long wall," as now generally in use, or the modes of splitting and crossing the air, as now used. We shall refer to those subjects under their appropriate heads. But, to give a concise history of the progress of the times, we may state the result of the improvement in mining has been a saving of one-third more coal than could be obtained by the old mode or that now generally in use in this country; while the

improvements in ventilation enable them, and also ourselves, to course from 40,000 to 150,000 cubic feet of air* per minute through the mine, when we could only force from 1000 to 10,000 feet by the old and natural processes.

The first mode of ventilation used was, of course, "natural," caused by elevating the "upcast," or exit, above the "downcast," or inlet. The next mode appears to have been by means of "waterfalls," creating a moving column of air by the means of falling water into the mine or shaft. The third, and that now generally in use, is the "furnace," which creates a draft by rarefaction, causing a rapid exit of the vapors or foul air of the mine, and a consequent influx to fill the partial vacuum. The fourth may be styled "the steam-jet," caused by the momentary impulse of rushing steam against, or in, the moving column of escaping air, which, of course, increases the movement at the point of vent; but in deep shafts the effects are lost, or partially so, before the column reaches its exit, from the fact that the steam loses its elasticity the moment it condenses. Steam acts like a wire spring, losing its power as soon as its elasticity is destroyed or at rest, which is quite the reverse of the furnace mode of ventilation.

The fifth and last mode of ventilation we shall mention is "mechanical," caused by the operations of a fan or other machinery, which draws the foul air from the mines, and, consequently, the atmospheric air fills its place. This mode we think the most perfect in use, and is now fast superseding all others.

Since the age of improvement has not gone by, we may mention a late invention in the economy of mining which may fairly be classed with the most important of the past or present in this respect,—the application of machinery to the work of mining in place of the thousands of men who now dig our coal by the most tedious and slavish labor known.

A great many coal-cutting machines are now in successful use, driven or operated by steam, water, or compressed air. Their universal application to all bituminous or moderately flat veins, where mining is extensively carried on, is only a matter of time. Not only their cheapness and superior effectiveness entitle these "iron miners" to favor, but a means is offered of working smaller seams, and deeper, warmer, and more gaseous basins; since the air they breathe—when worked by condensed air—improves instead of vitiates the mine.

In the process of manufacturing iron, the improvements did not cease with the change from charcoal to coke. It was but the dawn of the great iron-trade of Britain, and the mode was as primitive as the times.

Furnaces increased in size and capacity. From 5 they increased to 10

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* The quantity of air forced or drawn through the Hetton colliery, England, is 176,000 cubic feet per minute.

tons per week, and from 10 tons per week they were soon increased to a production of 50 tons, which was about the mean of the 280 furnaces in

FIG. 12.

"THE IRON MINER."

blast during 1826. But the rapid increase from 1790 to 1826 was small in comparison with the increase of production from 1826 to 1850, or the *decrease* in the comparative prices. Some of this increase during the later period, as in the former, was owing to the enlargement of the furnaces, the improvement in machinery, and the greater experience and intelligence of the iron-masters. But the great improvement, and the one more than all others which has influenced the iron-trade, was the invention and application of the hot blast.

Its influence on the coke-iron was truly wonderful, but it was the soul of the anthracite blast-furnaces; without its aid the hard stone-coal of Wales and Pennsylvania—the pure, *natural cokes*—would have been unavailable for the production of iron.

As an instance of the great benefits derived from the use of hot blast in coke, we may note the influence on the productions of the Clyde Iron Works, Scotland.

At these works, in 1829, the cost of the coke, iron, and limestone required to produce one ton of iron by cold blast was £8 4s.; but in 1833,

when the hot blast was in full operation,—having been introduced in 1831, —with a temperature of 612° Fahr., the cost of making the ton of pig, including labor, &c., fell to £3 6*s.*; while the productions of the furnaces were nearly doubled. The cost, however, of pig iron in Great Britain has been put at £2, or $10, per ton, of late years.

In 1850 the cost at Merthyr,* in Wales, is given at £3 0*s.* 5*d.*; at Glasgow, Scotland, at £2 17*s.* 9*d.*

The gross make of coke in Great Britain in 1860 is estimated at 6,000,000 tons; of this amount, 2,500,000 were the products of the Northern coal-field in Durham and Northumberland. The present gross production of pig iron in Great Britain is estimated to exceed 5,000,000 tons per annum. To produce this, not less than from 2½ to 3 tons of crude coal per ton are required as a mean, which would exhaust about 3000 acres of a four-foot seam of coal per annum.

"It has been calculated that an acre of coal four feet in thickness produces as much carbon as 115 acres of full-grown forest; and that a bushel of coal,—84 pounds,—consumed carefully, is capable of raising 70,000,000 pounds one foot high; and that the combustion of two pounds of coal gives out power sufficient to raise a man to the summit of Mont Blanc, 15,668 feet high.

"The aggregate steam-power, estimated at 83,635,214 horse-power, of Great Britain and Ireland alone, is calculated as equal to 400 millions of men, or equal to twice the power of the adult working population of the globe."†

Wonderful as it may seem, the above calculation is practical; and we have no doubt but Great Britain really possesses a dynamic strength in iron and coal to the extent named, since we always calculate one horse-power as equal to the physical strength or exertion of seven men, which would give a laboring force of over 585,000,000 of men. To this, even the vast population of China is insignificant as a physical power or an industrial and productive force; but when it comes to forcing a steamship of 20,000 tons across the Atlantic at the rate of 300 miles per day, or a train of 400 persons at a speed of 60 miles an hour, there is no comparison in brute force.

EARLY HISTORY AND DEVELOPMENT OF THE ANTHRACITE REGIONS OF PENNSYLVANIA.

The early history of coal in America is much less obscure and uncertain than its history in England, for obvious reasons. In fact, the printers

* Cold blast is still used at Merthyr,—a seeming contradiction to the hot-blast theory, but this will be explained further on.

† North of England Institute of Mining Engineers, vol. xii., p. 162.

themselves were among the pioneers of our coal-mines: first to advocate the value of coal, first to embark in its development, and first to chronicle its success; though we cannot say they were the first to profit. We may notice the examples of Cist, Miner, and Bannan, whose names appear prominent in the early history of anthracite coal, and to whom we shall refer in the following pages.

Though the anthracite coals of Pennsylvania were the first of our coals to acquire prominence or reputation, they were not the first to be discovered or worked in this country.

The bituminous coals of Richmond, Virginia, were the first to be developed, and enjoyed a trade with Philadelphia, New York, and Boston as early as 1789; while it had been used pretty extensively in the vicinity of the mines as early as 1775, and, during the War of Independence, was used at Westham, on the James River, five miles above Richmond, for the manufacture of shot, shell, &c., or until destroyed by the traitor Arnold in 1781.

It must have been discovered and worked as early as 1750. The writer has seen oak-trees, at least one hundred years of age, growing on the coal-banks of the old excavations, which, like all the primitive developments of the kind, were simple quarries or open cuts on the outcrops of the seams. Tradition says the coal of the Richmond field was first discovered by a boy who was digging for "crawfish" as bait when on a fishing excursion.

THE WYOMING VALLEY.

The first authentic account we find of the practical use of anthracite coal is in 1768–69, when it appears to have been first used by two blacksmiths from Connecticut, by the name of Gore, who had settled in the Wyoming Valley. This was the first successful and practical application of stone-coal, or anthracite, in this country, and inaugurated its use by the smiths of that region generally. Judge Obadiah Gore, one of the brothers alluded to, subsequently stated the fact as set forth to Judge Jesse Fell, of Wilkes-barre, who in turn communicated the interesting data to Silliman's Journal and Hazard's Register. We state this particularly, since there has been some doubt as to the priority of development in the several regions.

The discovery of coal in the Wyoming Valley must have been soon after its settlement by the "Yankees" in 1762. The coal crops out in so many places among the rocks of the valley, and in such conspicuous localities, that the early settlers could not avoid seeing it; and as many of them were intelligent men, and some of them undoubtedly familiar with the bituminous coals of the mother-country, it is not at all surprising or strange that the first practical development should have been in this region.

The difficulty of igniting anthracite, or of burning it without an arti-

ficial blast, prevented its use generally in the place of wood; while the cheapness and abundance of this as a fuel were adequate to the wants of

THE WYOMING VALLEY FROM PROSPECT ROCK.

the times, and there was no inducement for the introduction of mineral coal.

The ironsmith—or "blacksmith," as we call him—has ever been the pioneer among the useful minerals of the earth, as he has been our master mechanic from time immemorial; and he, as usual, was quick to appreciate the value of anthracite.

From the time of Obadiah Gore's first experiment in 1768–69, the coal-trade of Wyoming has been steadily growing,—imperceptibly at first, but advancing subsequently with rapid strides. In 1776, or at the commencement of the Revolutionary War, coal was taken in arks from the Wyoming mines down the Susquehanna to the Government arsenal at Carlisle, in Pennsylvania, and this was continued during the war.

The coal was mined, or rather quarried, at the locality now known as the Baltimore or Hollenback mines, above Wilkesbarre, and from the old "Smith Mine," in the vicinity of Plymouth.

The trade in arks on the Susquehanna seems to have been continued after the war, until the completion of the North Branch Canal, but exclusively for the use of smiths or forges. It was not until 1808 that stone-coal or anthracite was first used in grates for domestic or other purposes than the smithery.

The late Judge Jesse Fell of Wilkesbarre appears to have been the first of whom we have any authentic record who used this coal successfully in the common grate or for domestic purposes.

"He believed that our coal could be burned in grates. He judged, correctly, that the natural draft occasioned by a fire would be sufficient if the coal were only placed in a proper position. It is rational to believe that these were his views; for his first experiment, known to his descendants now in town, was made with a *wooden grate*, very much in the form of those now in use. It is amusing now to think of burning coal in a wooden grate; but his logic and economy were based on sound principles. He reflected, no doubt, that if he could make his fire burn so freely as to destroy his wooden grate he could then well afford to make one of iron, and could do so without fear of loss or disappointment.

"We know not the result of this first experiment, or any of the particulars; but the inference is reasonable that he succeeded, for his next experiment was more public. One of his daughters, the wife of Col. J. J. Dennis, lately deceased, told me that she well remembered the circumstances attending it. The judge was a practical man, and something of a mechanic. She recollected his going into the blacksmith-shop of his nephew, Edward Fell, and of his working with him most of the day fashioning an iron grate.

"Late in the afternoon he brought it home, and set it up with brick, in the fireplace of the bar-room. By evening he had kindled in it, with oak wood, one of the best of coal fires. The interest this excited, and the many visits of curious neighbors, anxious to see a stone-coal fire, were also well remembered by Mrs. Dennis. I was an inmate of her house when these facts first came to my knowledge. I had taken down from their library a book entitled 'The Free-Mason's Monitor,' and found upon one of its fly-

leaves, in the clear, bold handwriting of Judge Fell, which I had learned to know from the records of our county,—the following memoranda:—

"Feb. 11, of Masonry 5808.—Made the experiment of burning the common stone-coal of the valley, in a grate, in a common fireplace in my house, and find it will answer the purpose of fuel, making a clearer and better fire, at less expense, than burning wood in the common way.*

"Borough of Wilkesbarre,
February 11, 1808.

(Signed,) JESSE FELL."

Following this development, coal soon became a staple article in the valley, and mining a business, though but primitive at first. Coal sold in Wilkesbarre, about 1790, for domestic purposes, in small quantities, at $3 per ton, and in Marietta, on the Susquehanna, for $8 to $9 per ton, from 1810 to 1814. Previously, we presume, it must have been higher, as subsequently it became lower.

The coal-trade of Wyoming did not expand rapidly or increase in proportion to the subsequently developed regions of the Lehigh and the Schuylkill. The want of avenues to the great coal-consuming marts was long felt by the miners of the Valley.

Though the Pennsylvania Canal (now the Wyoming) was opened at a comparatively early day, the markets in that direction were limited, and the vend but small. In 1842 we find the first statistical return as 47,346 tons. But during the same year 205,253 tons were sent from the eastern end of the Wyoming coal-field, by the Delaware & Hudson Canal Company.

This company had completed a line of canal from the Hudson to Honesdale, Pennsylvania, a distance of 108 miles, and a railroad 15 miles long, over a mountain 1000 feet high, at a total cost of about 7,000,000 of dollars, for the sole object of reaching the coals of the Valley.

This great enterprise was completed in 1829, and 7000 tons of coal were sent to New York during that year. Since then the shipments over this line have reached 1,561,203 tons per annum, being the amount shipped during 1864. But 836,792 tons of this amount were mined by the Pennsylvania Coal Company, whose coal goes over the same line.

Notwithstanding the large amount of capital originally invested by the Delaware & Hudson Canal Company, it has been perhaps the most successful coal company ever organized. For nearly 35 years its dividends have been large, and its operations wisely and practically conducted.

In 1846 the Lehigh & Susquehanna Railroad, from the Lehigh Canal at White Haven, to a point near Wilkesbarre, was opened, and 5886 tons

* Lecture on Mineral Coal, by V. L. Maxwell, Esq., of Wilkesbarre.

of coal sent over the mountains to Philadelphia, *via* this and connecting lines.

In 1854 the Delaware, Lackawanna & Western Road was opened from Scranton towards New York, connecting with the Jersey Central. Over this line 133,963 tons were sent that year.

The North Branch Canal to the State line north, and the Lackawanna & Bloomsburg Railroad leading south, were next finished. These lines give six outlets to the coal-trade of the Wyoming region.

Though late in acquiring the means of transportation, the facilities of the Valley are now greater than those of any other region, and its productions are fast assuming overshadowing proportions in comparison with the trade of the earlier-developed anthracite coal basins. Below we give the shipments of these lines during 1864, which may be contrasted with the shipments of 1842, which were 252,599 tons, or those of 1829, which were perhaps less than 10,000 tons.

Shipments of coal from the Wyoming Coal-Field during 1864, and the leading lines.

North Branch Canal, leading north	156,103
Lehigh & Susquehanna Railroad, east to Philadelphia	132,213
Wyoming Canal, leading south	573,146
*Lackawanna & Bloomsburg Railroad, 516,473	300,000
Pennsylvania Coal Company, via Delaware & Hudson	836,792
Delaware & Hudson Canal Company	924,411
Delaware, Lackawanna & Western Railroad	1,382,146
	4,304,811

NOTE.—This return is at 2000 pounds to the ton, and, consequently, will not agree with the tables given elsewhere.

This wonderful increase has been realized principally since 1850. Only 827,823 tons were sent from the Wyoming region during that year.

NOTE.—In offering this brief and connected history of the development of our coal-fields, we can only glance at the leading features, but would here refer our readers to the detailed and local descriptions, which will be found under their appropriate heads as referred to in the Index and chapters.

LEHIGH REGION.

The discovery and practical development of coal in the Lehigh region were subsequent to its use in the Wyoming Valley, but the coals of the Lehigh were the first to realize a commercial value in the Eastern markets; consequently, the Lehigh coal-trade heads the statistical column, though it

* This line is a partial feeder to the Delaware, Lackawanna & Western, and probably not more than one-half its tonnage can be credited to the production of the valley, since part is included in the shipments of the Delaware, Lackawanna & Western Railroad.

is a matter of conjecture whether the Lehigh or the Schuylkill furnished the first coal for actual consumption,—that is, which *would burn*. We give the credit to Schuylkill.

When we read of the early attempts to burn anthracite or stone coal,

FIG. 18.

DISCOVERY OF ANTHRACITE COAL.

and the repeated failures even under steam-boilers and in furnaces built to burn bituminous, we are tempted to state that the miners of that day did not know coal from *bone* or *slate*, and that we suspect they sent all to market as it came from the mines,—coal, dirt, and impurities. Such we believe to be the chief reason why coal "would not burn" in those early days, as it is deemed a good reason now. But let us follow our pioneer miners through their "sea of troubles."

The first discovery of coal on the Lehigh was in the Mauch Chunk or Bear Mountain,—a continuation of the Sharp Mountain,—about nine miles west of Mauch Chunk, and where the village of Summit Hill is now located. Though denominated the "Lehigh Region," this portion of the Lehigh coal is in the Schuylkill or southern coal-field, and at its eastern end.

The discovery of coal in this locality was made during 1791 by a poor hunter of the vicinity,—the famous *Philip Ginter*. We will let him tell his own story, or that which is so frequently told for him:—

"When I first came to these mountains, some years ago, I built a cabin on the east side of the mountain, and managed, by trapping and hunting, to support my family in a rough way. Deer and bears were pretty thick, and during the hunting seasons meat was plentiful; but sometimes we ran short of that, and frequently were hard up for such necessaries as could only be had by purchase with the produce of the hunter.

"One day, after a poor season, when we were on short allowance, I had unusually bad luck, and was on my way home, empty-handed and disheartened, tired, and wet with the rain that commenced falling, when I struck my foot against a stone and drove it on before me. It was nearly dusk; but light enough remained to show me that it was black and shiny. I had heard of 'STONE-COAL' over in Wyomink, and had frequently pried into the rocks in hopes of finding it. When I saw the black rock, I knew it must be stone-coal, and on looking around I discovered black dirt and a great many pieces of stone-coal under the roots of a tree that had been blown down. I took pieces of this coal home with me, and the next day carried them to Col. Jacob Weiss, at Fort Allen.

"A few weeks after this, Col. Weiss sent for me, and offered to pay for my discovery if I would tell him where the coal was found. I accordingly offered to show him the place if he would get for me a small tract of land and water-power for a saw-mill that I had in view. This he readily promised, and afterwards performed. The place was found, and a quarry opened in the coal-mountain. In a few years the discovery made hundreds of fortunes; but I may say it ruined me, for my land was taken from me by a man who said he owned it before I did, and now I am still a poor man."*

Col. Weiss took the specimen of coal which he had received from Ginter to Philadelphia, and submitted it to the inspection of men of eminence and scientific attainment, who pronounced it, after much study and investigation, to be *stone-coal*,—a fact which Philip had determined in advance.

John Nicholson, Michael Hillegas, and Charles Cist—an intelligent printer—were satisfied of its value and quality, and sent word to Col. Weiss to satisfy Ginter, on condition of his showing the locality of the coal; and this was done, as before related by Ginter himself.

In the following year, 1792, Hillegas, Cist, Weiss, and others formed the "Lehigh Coal-Mine Company," and took up about 6000 acres of coal land, which has since formed the coal territory of the "Lehigh Coal and Navigation Company,"—formed by the subsequent amalgamation of the Lehigh Coal-Mine Company and the Lehigh Navigation Company.

The original company, composed of Robert Morris (the celebrated finan-

* This is substantially as the story was told by Ginter to a friend some years after the discovery. Of his history, adventures, or subsequent life we find no data, and have never heard whether he received reward or employment from the great company whose foundations he laid.

cier), J. Anthony Morris, Cist, Weiss, Hillegas, and others, organized an expedition in May, 1792, to open the mines. Four miners and one of the company formed the mining force. The coal was soon found without limit, and several tons were dug up. There was plenty of coal, and but little trouble to mine or quarry it. But what to do with it was the question. The coal existed in the midst of a wild and mountainous region, surrounded by unbroken, primitive forests, only traversed by the war-paths of the Indians or the courses of the hunters. The nearest market was at Philadelphia, over a hundred miles distant; and even that was a doubtful dependence, since mineral coal of any kind was but little used, and anthracite or stone coal was then a novelty.

On becoming satisfied of the value and extent of the coal deposits, the company suspended operations at the mines, and commenced to operate on public opinion and create an interest and a market.

Col. Weiss always carried samples in his saddle-bags, and never lost an opportunity to introduce his stone-coal to notice, or passed a blacksmith without urging on him the value and uses of the new fuel.

But the public generally are always doubtful, and in this case the "black rocks" of the Lehigh Coal Mine Company were a subject of much suspicion and ridicule.

In 1798 the Legislature chartered a joint-stock company to improve the navigation of the Lehigh, and some $30,000 were expended in clearing the rocks from the shoals and constructing wing dams. In 1803 the Lehigh Coal Mine Company again resumed operations at their mines, and six arks were built at Lausanne, on the river, above Mauch Chunk, ready for the first freshet to float them to Philadelphia *via* the Lehigh and Delaware Rivers.

The coal was hauled from the mines to the river, some nine miles, by horses, and the arks duly started with about one hundred tons each, and manned respectively with six men to the float.

For the first 15 miles the river is very rapid, the fall being about 20 feet to the mile, but not equally distributed, the descent being concentrated at the rapids or shoals. Those familiar with the rafting of timber down the rivers of Maine, or our own Susquehanna, or even the mode which has been practised for the last 20 years on the Coosa in Alabama, may form some faint conception of the perils and excitement attending this early navigation of the Lehigh.

Of the six arks thus started on their perilous trip, only two reached Philadelphia, with less than two hundred tons of coal. But the difficulties of finding purchasers were equal to the difficulties of reaching the market. No one wanted it, and none cared to experiment. At length the city authorities purchased the coal for the purpose of working a steam-engine which was then located in Broad Street to pump water for the supply of

the city. The trial was a failure. The stone-coal could not be made to burn; it was rejected as worthless rocks, and broken up to gravel the foot-walks of the grounds.

FIG. 14.

COAL-ARKS DESCENDING THE LEHIGH.

This experiment dampened the ardor and disappointed the hopes of the coal company, and for the next seventeen years ensuing they did not meddle with *stone-coal* on their own responsibility; but several leases were granted to sanguine individuals whose faith remained unshaken.

William Trumbull, Esq. had an ark-load of anthracite brought to the city of Philadelphia in 1806, but with no better success.

In 1813 the Hon. Charles Miner, Jacob Cist (son of Charles Cist), and Mr. Robinson, all of Wilkesbarre, leased the mines of the Lehigh Coal Mine Company, and commenced their operations; but before they were ready to ship coal, Mr. Robinson withdrew from the enterprise. At length, however, in the spring of 1814, they started five ark-loads of coal down the Lehigh; only two reached Philadelphia, but the coal they contained was sold, at 21 dollars per ton, to Messrs. White and Hazzard, who were manufacturing wire at the Falls of the Schuylkill.

This cargo of coal had been preceded by a few wagon-loads from Schuyl-

kill County, which were taken to Philadelphia, by Col. George Shoemaker, early in 1812, and which was the *first anthracite or stone coal successfully burned for practical purposes in that city.*

The secret or mystery of burning anthracite had been discovered by accident. It was found that closing the furnace doors and leaving the *coal alone* were the simple remedies; that *draft*, and the passage of the air through the heated mass, creating a natural *hot blast*, were essential to the economical combustion of anthracite. But this incident will be related more at large in connection with the history and development of the Sckuylkill region.

Messrs. Miner and Cist found, on counting the cost, that coal-mining at that early day, and under the circumstances, was a losing business, and if continued would be ruinous; and, consequently, they abandoned the enterprise, after sinking considerable capital in the Lehigh coal trade.

Young Jacob Cist was an intelligent and scientific man, and more familiar with mercantile and literary attainments than the original and practical knowledge required for the development of a new and savage region.

The late Hon. Charles Miner was too well and favorably known at home to need eulogy at our hands. He represented old Luzerne, then embracing all Northeastern Pennsylvania, in the Legislature, and subsequently Lancaster, Chester, and Delaware Counties in Congress. He published the "Gleaner," and the "Village Record," for a long period, and was a forcible, ready, and practical writer, the author of the History of Wyoming, and other works and papers of importance to the history of our country and times.

He wrote the first essays on the development of the anthracite coal-fields, and presented in detail many of the public improvements which have since been erected as a monument to his foresight and practical sagacity. It is remarkable, also, that he recommended a *railway* from Wilkesbarre to the Lehigh as early as December, 1813, before railroads existed, and when not one in a thousand could know what a railway was.

But Mr. Miner was not the only man deserving the notice of the historian, in connection with the development of our coal-fields. Josiah White and others have left practical monuments of utility, but none, like Miner, have left their thoughts and actions so publicly recorded: we will, therefore, be excused if we seem partial, and plead the want of time and space for further personal remarks.

In 1820 the navigation of the Lehigh was so far improved as to admit the descent of arks with comparative safety, and during that year 365 tons of coal were shipped to Philadelphia, and sold at $8.50 per ton; and from this time the Lehigh coal trade has been steadily on the increase. During 1864 it amounted to nearly 2,000,000 tons. The 365 tons, or one ton a

day, of 1820, heads the statistical column of the anthracite, or we may say the American coal trade.

In 1832 the Lehigh navigation was further improved from the primitive wing dams and sluices, which admitted the passage of loaded arks, but not their return, to a slack-water navigation, with locks and dams. In its present condition the canal is 48 miles long, 45 to 50 feet wide at the bottom, 60 to 100 at the top, and six feet deep. The locks are 22 feet wide and 102 feet long. The total cost of canal and fixtures to 1864 is $4,455,000. The amount of coal transported during the same year was 847,123 tons, and the total amount from the commencement of the trade in 1820 was 20,000,000 tons by canal.

FIG. 15.

GREAT OPEN QUARRY OF ANTHRACITE COAL.

Previous to the year 1847 the Lehigh Company obtained all the coal which they sent to market from their great open quarry on the Mauch Chunk Mountain at Summit Hill, and on the identical spot where the "stone-coal" had been discovered by Philip Ginter.

This celebrated quarry has been an object of great curiosity to thousands. It was a scene not presented by any of the mining districts of the world; for here a single vein of coal reached the enormous maximum thickness of seventy feet, or equal to the workable thickness of the entire formations of the richest coal-fields of the Old World.

Here the coal was not mined in the ordinary manner, but quarried in the daylight from an uncovered face of coal that would average 50 feet in

perpendicular height. This quarry has been abandoned since 1847. The excavation or place formerly occupied by the quarry will cover an area of 30 or 40 acres, and the amount of coal shipped from the quarry probably exceeds 2,000,000 tons. In 1840 the amount excavated was 30 acres, or 1,100,000 tons.

THE FIRST RAILWAY.

The *first railroad* of any note,—except a short one of three miles at Quincy, Massachusetts,—in this country, was constructed from Mauch Chunk to the Summit Mines, a distance of nine miles, in 1827. This was and is a gravity road, having a descent from the mines to the river of about 100 feet per mile. At first the mules which hauled back the trains *rode down* with the coal in a car constructed for the purpose, and could not be forced to *walk* down after having enjoyed the luxury of riding. By this novel contrivance two and a half trips, or 40 miles per day, could be accomplished. An improvement, however, was subsequently adopted, and stationary engines fixed at each terminus of the track, by which the empty cars were drawn to the summit of the mountain and returned again to the mines by gravity. In 1831 a locomotive road was constructed to the eastern extremity of the company's mines at "*Room Run*," where 14 seams were developed in 1830, with an aggregate of 240 feet of coal.*

In 1837 the Lehigh & Susquehanna Railroad was commenced, from White Haven to the Wyoming Valley, a distance of nearly 20 miles. This road was completed about 1845. The first shipment appears in 1846, of 5886 tons.

The Beaver Meadow Railroad, opening out the Beaver Meadow basin, and the Hazleton Railroad to the Hazleton basin, were in operation in 1840; the Buck Mountain Company's road was nearly ready for operation in the same year.

The Lehigh Valley Railroad was opened in 1855, transporting 9003 tons of coal, and during 1864, 1,295,419 tons; the total amount shipped from the Lehigh region by both canal and railroad during the same year was 1,928,706 tons.

NOTE.—The original "Coal Mine Company" leased in 1817 their whole property and privileges to Messrs. White, Hazzard & Co. for 20 years, at an annual rental of *one ear of corn!* but they were bound to deliver for their *own* benefit, 40,000 bushels of coal annually in Philadelphia. These gentlemen formed their interests into a stock company,—the *Lehigh Coal Company*,—and also organized the *Lehigh Navigation Company*, afterwards amalgamated as the *Lehigh Navigation and Coal Company*, and subsequently changed to the *Lehigh Coal and Navigation Company*.

The stock of the old "Coal Mine Company" was bought up by the new organization. At first the shares, representing fiftieth parts of the whole property, were bought at $150

* These 14 veins are really but 7, being the north and south dips of the same basin: consequently, they are counted in this estimate twice.

per share; the last brought $2000 per share. The Lehigh stock has generally stood high in market. It depreciated, however, 20 per cent. when the workmen reported they had found the *bottom of the coal* at 60 feet.

THE SCHUYLKILL REGION.

In point of prominence and present development the Schuylkill region is the most important, and has more claims to the attention of the historian than either of those before mentioned, since in connection we must also include the history of the Mahanoy region, as an off-shoot or consequent result of the development of this. But in a consecutive detail of events it is of course best and proper to relate them in the order of their occurrence, as we have attempted to do, and thus for the first time presented to our readers a reliable historical account of the order in which our coal-fields have been developed.

The first traditional account we have of the discovery of coal in the Schuylkill region is about 1790, when Nicho Allen, a noted hunter and somewhat notorious character, who lived on the Broad Mountain at the "Black Cabin" or Big Spring, discovered stone-coal at the foot of the Broad Mountain about the period of which we write. No written account of his discovery has ever come to our notice, though we have often heard the traditional account. Some ten years ago we commenced to gather material for a work of the kind we are now writing, though circumstances prevented their use at the time, but we find them now available.

We will be as brief as possible, though we have no doubt our readers will be interested to know every incident and event relating to the early discovery and development of our celebrated and invaluable coal-fields.

Tradition says that Nicho Allen, *alias* the "Black Yankee," discovered stone-coal during one of his hunting expeditions, in the following manner. Allen had camped for the night, which he frequently did, under the shelter of some overhanging rocks and trees, the precise locality of which is not mentioned; but, having built a fire on some fallen rocks, he stretched himself to sleep as near it as was safe. Some time during the night, when the wood should have been burned to embers, leaving the fire low, Nicho was surprised to be awakened by more heat about his legs than was comfortable; but he was astonished, on rubbing his eyes and his shins, to find the rocks a glowing mass of fire, and the mountain, as he supposed, in danger of being consumed.

This appears to have been Allen's first experience with stone-coal. In the morning he found the rocks were black and shining, and corresponding to the description he had heard of stone-coal; he consequently congratulated himself on his discovery, having such ocular demonstrations of its value as a fuel, and during the many years that followed, before the virtue of anthracite was fully recognized by the doubtful and unappreciative

public, Nicho Allen was its firm and steadfast advocate. But, like most of those early pioneers, he did not appear to have profited much by discovery or experience.

The last we heard of him was on the occasion of his death; which, if we

MAUCH CHUNK, FROM MOUNT PISGAH.

mistake not, was in an attempt to cross the Mahanoy on a slender foot-bridge or log, during a heavy flood, when he fell off and was drowned before assistance could reach him.

He had removed back to his native State in New England, in disgust with his success at coal-mining; but, having acquired a property in the Mahanoy Valley, the accident we have just related occurred while he was on a temporary visit here to look after it.

Such, we believe, were the facts, as correctly as they are generally given by tradition. Several versions of the same story were told by the associates of Allen, but they are all substantially the same. We have no doubt but this incident attracted attention at the time, and was the first information we possess of the discovery of anthracite coal in the mountains of the Schuylkill, which led to practical results.

The next notice we find of the use or existence of anthracite coal in the Schuylkill region is in the Transactions of the "Coal Mining Association of Schuylkill County," in which it is stated that a blacksmith, by the name of Whetstone, used it in his smithery about the year 1795. His success induced several others to dig for coal, and, when found, to attempt to burn it; but the difficulty was so great, they gave up in disgust. We have no doubt, as before stated, that one chief cause of their failure was owing to their ignorance of the difference between coal and slate. It is reasonable to suppose that our primitive miners(?) had but small experience in this matter, and that they dug all their coal from the imperfect outcrops of the seams.

About the year 1800, we learn from the same source, a Mr. William Morris, who owned a large tract of land near Port Carbon, procured a wagon-load of coal, we suppose from his own land, and took it to Philadelphia; but he was unable to bring it into notice, or induce the honest Quakers to buy his *rocks*, any more than his successors in the trade from the Lehigh. He returned, sold his lands, abandoned his plans, and retired from the business in disgust. The coal-trade of the Schuylkill did not revive from this shock until 1806. But about this time coal was found in cutting the tail-race of the Valley Forge, on the Schuylkill. It was tried by David Berlin, a blacksmith of the neighborhood, with complete success: they had stumbled on some *good coal*, and from that time stone-coal grew into repute among the smiths of the Schuylkill, as it had, long before, grown in favor with the Vulcans of Wyoming and the Susquehanna.

In 1812, Col. George Shoemaker, of Pottsville, loaded nine wagons of coal from his mines at Centreville,—a locality now abandoned, on the main turnpike road from Pottsville to Ashland, and about a mile from Pottsville,—and with these proceeded to Philadelphia, hoping to find a market. But the experience of the Philadelphians with anthracite or stone coal was very unfavorable at that period; the frequent and persistent attempts to impose *rocks* on them for coal had roused their indignation, and Col. Shoemaker was denounced as a knave and a scoundrel!

Col. Shoemaker persisted, however, and disposed of two loads, at the

cost of transportation,—one to Messrs. White & Hazzard, of the Fairmount Nail and Wire Works, at the Falls of the Schuylkill, and the other to Messrs. Mellon & Bishop, of the Delaware County Rolling-Mill. The remaining seven loads he either gave away, or disposed of to blacksmiths and others who promised to try it, for a trifle. But the colonel was not to get off so easily. Though he lost money, time, and trouble in his attempts to introduce a fuel which has since made Philadelphia one of the most wealthy and prosperous cities in the world, the very men to whom he had *given his coal* obtained a writ from the authorities of that city for his arrest as an impostor and a swindler. Col. Shoemaker was forced to beat a hasty retreat, and only saved himself from persecution and "*justice*" by taking a wide circuit around the Quaker City on his way home.

In the mean time, Mr. White, who was anxious to succeed in burning this coal, and some of his men, spent a whole morning in trying to ignite it and raise a heat in one of their furnaces. They tried every possible expedient which skill and experience in other fuels could suggest. They *raked* it, and *poked* it, and *stirred* it up, and blew upon the *surface* through *open-furnace* doors, with perseverance and persistent determination, but all to no purpose. Col. Shoemaker's rocks would not burn, and the attempt was abandoned. But dinner-time had arrived, and the men shut the furnace-doors in disgust, heartily tired of the stones, or stone-coal, if such it was.

Returning from dinner at the usual time, all hands were astonished at the phenomenon which they beheld. The furnace-doors were red-hot, and the whole furnace in danger of being melted down with a heat never before experienced. On opening the doors, a glowing mass at white-heat was discovered. So hot a fire had never been seen in the furnace before. From this time anthracite or stone-coal found friends and advocates in Philadelphia, and the motto "let it alone" became a receipt for its use rather than its abuse.

Messrs. Mellon & Bishop also succeeded, about the same time, in using successfully the load of coal they had obtained from Col. Shoemaker; but it appears evident they took the hint from the motto adopted at the Falls of the Schuylkill, and acted accordingly.

The result of these successes got into the papers, and the press, as usual, soon gave it reputation. Everybody knew stone-coal was coal, as soon as somebody proved it such.

In 1814 the Schuylkill Navigation was projected, and so far completed in 1822 that 1480 tons of coal were sent down; but not until 1825 was the navigation in a condition to pass boats to and from Pottsville and Philadelphia; and in the mean time the coal-trade of the Lehigh had been opened, mainly through the exertions of Messrs. White & Hazzard, who devoted their time and their means with the most determined perseverance

to what was then a herculean task, and beset with difficulties and risks of the most formidable character.

Though a small quantity of coal was sent down the Schuylkill Navigation each year from 1822, it was not until 1825, when 6500 tons were sent down, that we can fairly date the commencement of the trade from this region. From that time it has increased rapidly, and in the year 1860, 1,356,688 tons were transported over the canal alone. It was not until 1841 that the Reading Railroad was open to the coal-trade, and 850 tons transported over it to market. Last year, or 1864, 3,065,577 tons went over this railroad to Port Richmond,—the shipping-point on the Delaware.

The first attempts to mine coal were rude and simple. A shaft or pit was sunk a few feet on the outcrops of a seam, and the coal raised by means of a common hand windlass. It was sold to smiths and others in the vicinity at twenty-five cents per bushel, or about $5 per ton. Subsequently, or about 1823, an improvement was made by substituting horse-power, and gins, or "horse-whims," for the windlass. When the shaft, or works, became from 30 to 50 feet deep, and the water troublesome, the establishment was removed and a new shaft started. No system was pursued in mining the coal, but all within easy reach at the bottom of the shaft was extracted, and the place abandoned to fill with water; which afterwards proved a source of expense, annoyance, and danger to mining operations in the vicinity.

Fig. 16.

DRIFT, OR WATER-LEVEL.

Drifts had been run in on the level of the veins at an early date, when the discovery of coal happened to be at localities—at the foot or on the side of a hill—where this mode was applicable. The coal was then brought out in wheelbarrows.

It was not until 1827 that rails were used in the mines; and up to 1829 the coal was carted over common mud-roads from the mines to the canal. This year 79,973 tons were shipped.

Abraham Pott, of Port Carbon, was the first to build a model railroad in this region. It led from his mines to the canal, a distance of half a mile. Soon after, the Mill Creek Railroad was built from Port Carbon to the Broad Mountain, above the present town of St. Clair. The distance is about three miles. The cost was $5000. This was in 1829.

The Schuylkill Valley Road was completed in 1831, and extended from Port Carbon to Tuscarora, a distance of 10 miles; cost, $63,000.

The Norwegian & Mt. Carbon Road was finished during the same year. It extended from Mt. Carbon to the forks of the Norwegian, about one mile, then branched up the east and west forks of that stream to Oak Hill on the west and Wadesville on the east. Length of road, between five and six miles; cost, $97,000.

The next constructed was the Mine Hill & Schuylkill Haven Road; length, 11 miles, or, with the west branch, 15 miles, and costing $182,000.

The Little Schuylkill Railroad, from Port Clinton to Tamaqua, 22 miles, was in course of completion in 1833. It was designed as a locomotive road,* but was not used as such until some years subsequent. The total cost of double track was estimated at $260,000.

A fair price for coal delivered in Philadelphia was estimated in 1833 at $5 per ton; thus:—

Delivered in boats at Port Carbon	$2.50
Toll on canal	1.00
Freight to Philadelphia	1.50
	$5.00

The growth of the coal-trade in the Schuylkill region was very rapid after the introduction of railroads, and increased from 79,973 tons in 1829 to 839,934 in 1844. The introduction of the steam-engine for hoisting and pumping at the mines, which had now, in many cases, been carried below water-level, also added to the facilities of mining. The first steam-engine was erected at the Delaware Mines in 1836.

In 1844 there were twenty-two collieries under water-level, at which there were twenty-eight steam-engines, with an aggregate of 1100 horse-power, engaged in hoisting coal and draining water. In addition, there were thirteen smaller engines erected during 1844 for the purpose of breaking and cleaning coal, in connection with the Batten Coal-Breaker, which had just been introduced. These increased the aggregate horse-power to 1278.† The first coal-breaker erected was by Mr. Gideon Bast, on Wolf Creek, near Minersville. It was driven by a twelve-horse

* The first locomotive used in this country was on the Carbondale & Honesdale Railroad, belonging to the Delaware & Hudson Canal Company, in 1828. It was designed to convey the coal-cars of this company from their planes to the Lackawaxen and return, but was found too heavy for their lightly-built road. All the railroads of that period were built of wood, and strapped with light plate-rails. We do not remember cast-iron tram-rails as used to any extent at the anthracite mines.

† For the aggregate horse-power during 1864, we refer to the Tables in the Appendix.

engine, and was capable of breaking and cleaning 200 tons of coal per day,—or equal to the labor of from 50 to 60 men per day. At present, our large establishments are capable of preparing from 500 to 1000 tons per day.

The first successful use of anthracite in this country for the purpose of smelting iron was made in 1839, at the Pioneer Blast Furnace, in Pottsville. This furnace was built by Mr. William Lyman, of Boston, about the time or soon after the successful use of anthracite by Mr. George Crane, of the Gnyscedlyn Iron Works, in South Wales.

The Pioneer furnace was then managed by Mr. Lyman and Benjamin Perry, assisted by Mr. David Thomas, who has since been so remarkably successful on the Lehigh in the production of anthracite iron.

In 1826 an attempt was made on the Lehigh to use anthracite in the blast furnace, but failed, as all those early attempts did, simply for the want of a hot blast, as there has been no difficulty since its application in the production of pig metal with anthracite coal. But in 1839, soon after the successful result of the Pioneer furnaces, Messrs. Baughman, Ginteau & Co. started the Mauch Chunk furnace, but it did not continue long in operation.

The number of anthracite furnaces in operation during 1860 was 121. The production of iron in 1840 was 287,000 tons; in 1860 it had increased to 884,474 tons.* In 1840 the number of furnaces, principally charcoal, was 804; but in 1860 they had decreased to 580, of which only 416 were charcoal.

MIDDLE COAL-FIELD.

The western end of the middle coal-field, or, as it is called, the Shamokin region, was not practically developed until 1839, on the completion of the railroad from Sunbury to Shamokin, during which year 11,930 tons were shipped; but in 1864 the Shamokin trade had increased to 333,478 tons. Of the early history and development of this region we have but little information. We may mention, however, that the existence of coal in the middle field must have been known at an early day, as "coal" is marked in this locality on Scul's old map of Pennsylvania, and on Faden's Atlas of North America, as early as 1770–7.

The eastern end of the middle coal-field is known as the Mahanoy region, and is of late development. The first coal was shipped from the Mahanoy Valley over the mine plains and railroad in 1855, but so rapid has been the increase that in 1864 1,501,518 tons were shipped over the four railroad lines that now offer outlets to the coals of this rich valley.

* For later reports, see Tabular Statement in Appendix.

AREA AND PRODUCTION OF THE ANTHRACITE COAL-FIELDS.

	Area in Square Miles.
Wyoming or Northern Coal-Field..................	198
Middle Coal-Field, Shamokin Region.............	50
" " Mahanoy Region..............	41
Lehigh Basins..	35
Southern or Schuylkill Coal-Field.................	146
Total..................................	470

CUMBERLAND COAL-FIELD, MARYLAND.

We will merely notice in this connection the Cumberland trade, in order to give the date of its development.

The first appearance we find of the Cumberland coal in market is in 1820, when 70,000 bushels were sent down the Potomac in barges or arks; but the opening of the Cumberland coal-trade commenced in 1842, when there were shipped over the Baltimore & Ohio Railroad 1708 tons. We find no shipments by the Chesapeake & Ohio Canal until 1850, when 3042 tons were transported over that line.

The production of the Cumberland region was 657,996 tons in 1864, and the total amount produced to the same date, 8,446,229.

OTHER COAL-FIELDS.

It is impossible to give a connected statement of the early history and development of our Western bituminous coal-fields, generally. The area is so extremely extensive, and the localities so remote, and their histories so diffuse and uncertain, that nothing useful or instructive could be gained by the attempt. We will, however, give all that may be found valuable or interesting in connection with developed or prominent localities under the local heads farther on.

We may be safe, however, in stating the coal-production of the West to be fully 10,000,000 tons per annum. The only return we have is a partial statement for 1860:—

WESTERN COAL-PRODUCTS IN 1860.

Pennsylvania..............................	66,994,332	bushels.	
Ohio..	28,339,900	"	
Illinois..	25,000,000	"	
Indiana.......................................	15,000,000	"	
Virginia......................................	10,000,000	"	
At 30 bushels to the ton............	145,334,232	"	or 4,844,474 tons.

The products of other coal-producing Western States not included in the above estimate will swell the amount above 5,000,000 of tons. The coal-product of the West has also largely increased since 1860. In 1864 the Monongahela Navigation Company alone sent 35,070,917 bushels to market, an increase over 1863 of 8,626,665 bushels. In 1845 only 4,605,185 bushels were sent over this line.

CHAPTER VII.

COAL-FIELDS OF GREAT BRITAIN.

Variety and Character of Coal—Cannel, Bituminous, Anthracite—British Coal-Fields—Areas—Thickness of Coal and Coal Measures—Great Northern Coal-Field—Extent—Monk-Wearmouth Pit—Permian Strata—New Red Sandstone—Water—Immense Cost of Sinking—Dikes, Faults, and Errors—Natural Coke—Lower Coal-Beds—Coal-Seams—High Main—Low Main—East Somerset Thin Seams—Cost of Mining—Total Production of the Newcastle Coal-Mines—Names of Operators and Collieries—Production per Head—South Wales Coal-Field—Anthracite—Production—Uses—North Staffordshire Coal-Field—"Potteries"—Iron-Stone—Fire-Clays—"Punch and Thirl"—Longwall—Coal-Fields of France—Production of Coal and Iron—Coals of Belgium—Other European Coal-Fields.

VARIETY AND CHARACTER OF COAL.

THE coals of the Carboniferous era, or "true coals," as they are frequently called, may be grouped under several heads, or names:—Cannel, Bituminous, Semi-Bituminous, and Anthracite. Cannel is a remarkable variety, the coarser kinds being called "parret" in Scotland, and splint-coal in England and our Western coal-fields.

Cannel contains from 40 to 60 per cent. of volatile matter, and the proportion of carbon varies to the same extent. It takes fire like a candle, burns readily, and gives out much flame and smoke. The ash varies from 4 to 10 per cent. This is generally considered the best gas coal, since it produces large quantities and of a remarkably pure quality. It is found extensively in the Scotch coal-fields, and also exists to a limited extent in the Newcastle district; in the Wigan portion of the Lancashire coal-field, and in the Yorkshire and Derbyshire coal-fields.

Cannel coal passes into jet and asphaltum. It may be worked into ornaments, but is brittle and not very hard. The seams are generally thin, though there are important exceptions. The coal of the Mons basin, Belgium, seems to be of this kind. Cannel exists, to a great extent, in our Western coal-fields, of the richest and purest variety.

Cannel is a bituminous coal, but differing so much from our common bituminous, that it seems more appropriate to designate them by different names. Common bituminous contains less volatile matter, and may be said to yield from 50 to 75 per cent. of carbon, and the semi-bituminous from 75 to 90 per cent. of carbon.

The rich caking, or coking, coals of Northumberland and Durham contain from 60 to 70 per cent. of carbon, and from 2.50 to 5 per cent. of

ash; while the average yield of the Newcastle, or the Great Northern, coal-field, is from 70 to 75 per cent. of carbon. The variety known as "household coal" contains the largest amount of carbon, and those known as steam and gas coals the smallest amount of carbon, and, of course, the largest amount of volatile matter. The following analysis gives the approximate or average percentage of those coals, as presented on the authority of the North of England Institute of Mining Engineers.

		Household.	Gas.	Steam.	Coking.
Coke	Carbon	71.81	68.11	60.59	70.72
	Ashes	.58	.95	1.01	2.21
	Gaseous products	27.61	30.94	38.40	27.07
		100.00	100.00	100.00	100.00

The coking coal of this district leaves a red ash in an open fire, and requires to be deprived of its volatile matter before being exposed to a strong blast, owing to its tendency to cake or cement together in a solid mass, and thus prevent a free draught through the grate or furnace in which it may be used.

The coals of Staffordshire, Yorkshire, Derbyshire, Lancashire, North Wales, and many other districts, contain as much or more bituminous matter than those of Northumberland and Durham, but they do not cake or coke as well, and, consequently, may be used to a greater extent without coking. On account of its superior coking qualities, nearly half of the enormous coke production of Great Britain—6,000,000 tons—is made from the coals of the Great Northern coal-field. The coals of those districts named above burn freely, with much flame, and give out great heat, but they are considered inferior, for household as well as coke-making purposes, to the coals of the last-named field. They yield from 50 to 70 per cent. of carbon, and from 25 to 45 per cent. of volatile matter, with about 5 per cent. of ash, which is often white. Most of the coals of the inland counties show the presence of argillaceous earth by the white lines on the edges of the beds, and are, therefore, less adapted to general use than the Newcastle coals; but many of them are of excellent quality.

Next in order to the coals of the midland counties are those of North and South Wales, which contain a larger percentage of carbon generally than the coals named above, and, of course, less volatile matter and bitumen. They burn, however, freely, with but little smoke or residue, and are peculiarly adapted for steam purposes and the manufacture of iron, or where a strong blast is required. This character of coal is as extensively distributed as the coals before mentioned, and is found extensively in America, at Pittsburg in Pennsylvania, Ohio, Maryland, and elsewhere. It is also found and mined to some extent in France, Belgium, Saxony, and Austria.

The last variety among the true coals is anthracite, which consists almost exclusively of carbon. This is a non-bituminous coal, as the steam-coal is a semi-bituminous. We do not generally apply the term semi-bituminous in this country to the bituminous steam-coals of Cumberland and Blossburg, or those of the eastern limits of the great Alleghany coal-field; but they are nevertheless as genuine a semi-bituminous as the coals of Broad Top or Sullivan county.

Anthracite coal contains from 80 to 95 per cent. of carbon, with a small amount of ash generally, and sometimes a limited percentage of volatile matter. The anthracites are heavier than common coal, and take fire with difficulty, but burn with intense heat when fully ignited under a strong draft. This coal is found abundantly in South Wales and in Pennsylvania, and also exists in the south of Ireland, in France, Saxony, and Russia.

The use of this coal is greatly on the increase, though of late development. It is adaptable to a variety of purposes, but its chief use of late years has been for the manufacture of iron and for steam purposes generally, in the vicinity of its production. It was used exclusively by our war-steamers during the Rebellion, with the exception of our gunboats on the Western rivers. This coal is generally lustrous, with a bright, shining, irregular or conchoidal fracture; hard, dense, and tenacious, or without fracture during combustion, but sometimes brittle and friable under a strong heat, and not available for use in the blast furnace.

TABLE OF THE VARIETY AND CHARACTER OF COAL.*

Countries and Classifications.		Localities of Coal.	By whom analyzed.	Carbon.	Volatile.	Ashes.
I. Fat bituminous adhesive coal. The greater part close-burning or strong burning blazing coals.	America.	W. Pa., Ohio, Va., and Illinois...	....	52.0	44.0	4.0
	England.	Newcastle-on-Tyne, Bertley.......	Berthier.	60.5	85.5	4.0
	"	Northumberland, Tyne Works....	"	67.5	30.0	2.5
	"	Staffordshire, Apdale Works......	"	62.4	84.1	8.5
	"	Wednesbury	"	67.5	30.0	2.5
	"	Derbyshire, Butterly, Cherry.....	"	57.0	40.0	8.0
	"	Codner Park, Soft Coal.............	"	51.5	45.5	8.0
	"	Lancashire Cannel Coal.............	Karsten.	56.0	88.5	5.5
	"	Scotch, Lismahago...................	Mushet.	89.4	56.6	4.0
	"	Derbyshire, Morley P. K...........	"	45.0	45.0	10.0
	France.	Auzin	Berthier.	70.5	25.0	8.5
II. Dry coals, not adhesive; open-burning coals.	"	Riv. de Gier...........................	"	66.5	81.5	2.0
	"	St. Etienne	Gruner.	74.8	24.2	1.5
	Scotland.	Clyde, Splint Coal	Mushet.	59.0	86.8	4.2
	"	" Clod Coal, richest...........	"	70.0	26.5	4.5
	"	" near Glasgow	Berthier.	64.4	81.0	4.6
	"	Calder	"	51.0	45.0	4.0
	"	Monkland	"	56.2	44.4	1.4

* R. C. Taylor's Statistics of Coal.

TABLE OF THE VARIETY AND CHARACTER OF COAL.—*Continued.*

Countries and Classifications.		Localities of Coal.	By whom analyzed.	Carbon.	Volatile.	Ashes.
III. Less adhesive, or caking.	U. States.	Pennsylvania, Philipsburg	Johnson.	68.0	22.0	10.0
	"	" Karthaus	"	68.1	26.8	5.1
	"	Virginia, Richmond	Clemson.	64.2	26.0	9.8
	"	Illinois, Ottawa	Fraser.	62.6	35.5	1.9
IV. Steam-coals, very dry, with excess of carbon. Open-burning semi-bituminous.	S. Wales.	Dowlais Iron Works	"	79.5	17.5	3.0
	"	Merthyr-Tydvil	"	78.4	18.8	2.8
	"	Pen-y-Daran	Mushet.	86.0	12.0	2.0
	"	Aberdare	....	87.0	11.5	1.5
	"	Rhymney & Tredegar Works	Mushet.	81.0	15.0	4.0
	"	Steam, Pembrey & Llanelly	"	80.0	17.0	3.0
	Belgium.	Mons-Dour	Berthier.	85.0	12.7	2.3
	France.	Auvergne, St. Etienne	Gruner.	74.8	21.7	3.5
	U. States.	Dauphin county, Pa., Ratlin Run	Lea.	76.1	16.9	7.0
	"	Maryland, Mt. Savage	Jackson.	77.0	16.0	7.0
	"	Pennsylvania, Blossburg	Clemson.	75.4	16.4	8.2
	"	" Broad Top	"	70.1	16.7	13.2
V. Anthracite.	S. Wales.	Neath Valley	Mushet.	91.0	8.0	1.0
	"	Ystal-y-ferra	"	92.5	6.0	1.5
	"	Cwn-Neath	"	95.7	2.8	1.5
	U. States.	Pottsville, Pennsylvania	Rogers.	94.1	1.4	4.5
	"	Black Spring Gap, Pennsylvania	Lea.	88.6	7.1	4.3
	"	Mauch Chunk, Pennsylvania	Rogers.	88.5	7.5	4.0
	"	Sugar Loaf, "	Johnson.	90.7	7.0	2.3
	"	Rhode Island, Portsmouth	Jackson.	85.0	10.0	5.0
	"	Massachusetts, Mansfield	"	92.0	6.0	2.0
	Russia.	Territory of Don Cossacks	....	94.2	.....	.....

BRITISH COAL-FIELDS.

The coal-fields of the British Islands, as given by Dr. Ure,—from whom some of the foregoing facts are obtained, and who is generally very correct,—are more extensive than the areas we have adopted.

We give, however, below, an interesting table from his works, in which it will be observed there is considerable difference in the areas as given by us in Chapter V.

The area of the South Wales coal-field is less than our computation; but that of Ireland is far greater. The Irish coal-fields are not considered valuable or productive to a great extent, and mining operations are very limited, owing to the impurity and unproductiveness of the seams. We have given 250 square miles of available coal area out of more than 2000 square miles of coal formation; and this amount is in excess of that given by most of the late English authorities.

Our estimate of the coal resources of Great Britain is also in excess of the estimates of her modern engineers, though we give only 6195 square miles of productive coal area, while Dr. Ure gives 8800. The addition,

however, of 200,000 acres to the South Wales coal-field and the subtraction of 1,690,000 acres from the coal-fields of Ireland will reduce Dr. Ure's estimate to about the proportion we have adopted.

Estimates of the total amount of coal contained in a given area are by no means reliable: there are so many circumstances affecting the seams that no calculation, without a practical computation of the amount of coal in each seam, can be even an approximation to the truth. But few of the coal-seams underlie the whole area of any coal-field; some of them are lost or become valueless in the deep basins, or in opposite directions, while dikes, faults, and other interruptions seriously depreciate the amount of available coal, and erosion or denudation affects it still more.

Much discussion has taken place recently in regard to the probable duration of the British coal-fields under the present rate of production, which is not likely to diminish, since it has steadily increased for the last 500 years or more. But even at a maximum of 100,000,000 tons per year, it is estimated, by good authority, that the supply of coal in the British Islands will be exhausted within 300 years. Mr. Hull, Sir William Armstrong, and Prof. H. D. Rogers, now of the University of Glasgow, Scotland, place the limit at 212 years; while Mr. T. Y. Hall, an eminent mining engineer of the north of England, and Mr. Greenwell, a geologist of the same district, estimate the duration of the Great Northern coal-field at 256 years, under a production of 20,000,000 tons per annum, which is less than the present production.

No coal-producing country is so thoroughly developed as England,

TABLE OF BRITISH COAL-FIELDS.*

Names of the Principal Coal-Fields.	Estimated Workable Area, in Acres.	No. of Workable Seams.	Total Thickness of Workable Coal.	Thickest Coal-Seam.	Total Thickness of Coal Measures.
1. Northumberland and Durham	500,000	18	80	7	3000
2. Cumberland and Westmoreland and West Riding of Yorkshire	99,500	7	17	9	2000
3. Lancashire, Flintshire, and North Staffordshire	550,000	75	150	10	6000
4. Yorkshire, Nottinghamshire, and Derbyshire	651,500	12	82	10	2100
5. Shropshire and Worcestershire	79,954	17	40	......	......
6. South Staffordshire	65,000	11	67	40	1000
7. Warwickshire and Leicestershire	80,000	9	30	21	......
8. Somersetshire and Gloucestershire	167,500	50	90	7	5000
9. South Wales Coal-Field	[a]600,000	80	100	9	12,000
10. Scotch Coal-Fields	1,045,000	84	200	30	6000
11. Irish Coal-Fields	[b]1,850,000	9	40	6	......

a This estimate is 200,000 acres less than we have given elsewhere.

b This is 1,690,000 acres more than our calculation of productive coal area.

* Dr. Ure.

Fig. 17.

therefore we must adopt the later estimates as the most correct, though largely at variance with the eminent authorities from which our tables, in Chapter V. were compiled. But, it will be observed, in those tables we simply give the total coal areas, total thickness, and total assumed amount of coal, from the data thus furnished, without deductions for dikes, faults, waste, pillars, &c.; and, moreover, we calculated the production of all seams, from one foot up, instead of *three* feet, which the gentlemen above quoted take as a minimum workable thickness. We think, and there can be no doubt of it, when coal becomes scarce and high-priced in England, her engineers will find a mode to work many a small or abandoned seam which at present will not pay.

GREAT NORTHERN COAL-FIELD.

This coal-field is perhaps the largest in England. It was the first developed, and is of the greatest importance to the British coal-trade, since it furnishes nearly one-fourth of its production. The area of this field is calculated at 750 square miles, including only 50 square miles under the sea; but good authority, including the eminently practical opinion of Nicholas Wood, Esq., places half of the field or more under the North Sea, which would swell the area to 1400 square miles.

This field is generally known as the Newcastle coal-field, and is located in Durham and Northumberland counties. It extends from the river Tees in the south to the Coquet in the north; a distance of 48 miles, with a maximum breadth of 24 miles, or a mean of nearly 16 miles. The deepest coal that has been proved is the Hutton Seam, in the Monk-Wearmouth Pit, which is 1800 feet below the level of the sea, and its mouth one mile from its shores, the coal still dipping east, or under the sea. Below the Hutton are the Harvey and the Rock-

GREAT NORTHERN COAL-FIELD.

Explanations.—*Vertical Section at Monk-Wearmouth.*—*a*, Sea at the mouth of the river Wear; *b*, Monk-Wearmouth shaft; *c*, new red sandstone; *d*, high main coal; *e*, main coal or Wear; *f*, Hutton seam; *g*, Winn Sill. XIV. Magnesian limestone; XIII. coal measures; XII. millstone grit or conglomerate; XI. upper subcarboniferous; X. lower subcarboniferous; IX. old red sandstone. The lower coal series or subcarboniferous coals are between XI. and X. They are the same as our proto-carboniferous or false coal measures.

well seams, besides some five or six others, not now considered workable; the whole occupying some six or seven hundred feet of coal measures. Accompanying will be found a vertical section of this coal-field near the mouth of the river Wear, at the Monk-Wearmouth pit, which is 1800 feet below the sea-level, shown by the water-line crossing some hundred feet below the pit's mouth, on a level with the Wear, which enters the sea at Sunderland, one mile from this point. We have numbered the strata in the same manner as adopted in the Palæozoic strata of the Appalachian formation, figure 2, Chapter II. No. XIII. represents the coal measures; No. XII. the great conglomerate, or, as known in England, the millstone grit; No. XI. the great Carboniferous limestone, containing the upper and lower coal series. No. X. is the lower Carboniferous limestone,—the scar limestone, containing the lower coal series of the English formations, and synonymous with our protocarboniferous, or false coal measures. No. IX. is the famous "*old red sandstone.*" Above the coal, No. XIV., in this section, is the Permian formation, not shown in our Appalachian column, though probably existing. This is the *new red sandstone*, and the magnesian limestone, so peculiar to the great English coal-fields.

This Permian formation extends from the vicinity of Tynemouth, about the middle of the coal-field, to its southern extremity, on the Tees,—covering about one-fourth of the coal-field from 100 to 300 feet deep.

Through this, as will be noticed, the Monk-Wearmouth pit is sunk. It frequently happens that the cost of sinking through the Permian is enormous, owing to the sandstone underlying it being in the shape of quicksand, or full of great water-seams, which drain an immense area of country, or, perhaps, may be fed from the sea.

In one instance, at the "winning" of Murton colliery, 9000 gallons of water per minute were encountered in this sandstone, requiring the exertion of 1584 horse-power to work the pumps. The first attempt at the Haswel pit, or "winning," was abandoned after the expenditure of $300,000, in consequence of the excess of water; and in another case over $1,500,000 were expended in establishing a single colliery.

TRAP DIKES.

Another feature of this coal-field, and, in fact, of most of the British formations, are the numerous dikes of trap or basalt which cross them in a general east-and-west direction. The great 90-fathom dike of the Newcastle coal-field is the most peculiar. Its greatest thickness appears to be about 22 yards, while it extends in length almost across the north of England from the North Sea to a point near the Solway Firth in the Irish Sea. It forms an axis through the coal-field,—the seams on the north side dipping off from the dike at an angle of from one in six to one in four, as

a general rule. In many cases the seams are abruptly thrown up or down several fathoms by the numerous dikes which cross the field.

This feature of the English formations had led to much misconception of faults in general. Our readers may remember that *all faults* in coal-mines, as portrayed in works on geology, are of this class, following the "slip-dikes" or trap-dikes of the English coal-fields,—an abrupt termination, an "upthrow," or a "downthrow," being the general form portrayed; while, in fact, this form of fault does not embrace one-fifth the "troubles" found by the miner, and is altogether absent or extremely rare in the American coal-fields, owing, as we explained in Chapters III. and IV., to the venting of the volcanic forces at weaker points along the granite sea-coast line, and the yielding of the folded strata of the East to the forces of contraction. In the English formations those forces found vent in thousands of dikes, promiscuously scattered over the British islands, to the serious injury of their coal-fields.

THE WHIN SILL.

Another singular formation or feature of the Great Northern coal-field is the "*whin sill*," marked *g* in the section, which exists between the upper and lower Carboniferous limestones, and in the vicinity of the lower coal measures. This is a trap, or basaltic rock, spread over and between the limestones, and seems to be coextensive with the field. It evidently originated from some volcanic eruption of the time, and may have resulted cotemporaneously with some of the great dikes.

It is extremely doubtful that those dikes are the invariable formations of a period subsequent to the coal era, as many suppose, since the coal is only occasionally affected by the heat of those igneous rocks, as it would be were they injected through it. The coal has, in a few instances, been found charred near the dikes; but generally they simply terminate in their vicinity, as might be expected in the deposition of the coal-beds if subsequently formed.

We find cases of veins or seams being consumed to a cinder, and others charred to a perfect coke, by dikes of subsequent formation, which have been injected through or between the coals. The Tuckahoe portion of the Richmond coal-field, in Virginia, lying principally on the north side of the James River, is a case in point. Here we find a "whin sill" precisely similar to that of the Newcastle field in England, injected between two coal-seams, as may be seen in the sections illustrative of the Richmond field. The trap found a vent beneath the upper seams of coal, which it burned to a complete cinder, while the succeeding seam below was formed into a beautiful and useful natural coke, which is in great demand as a household fuel.

The lower coal measures of the English formations are fully developed

in the Great Northern coal-field. The seams of coal in this lower series crop out in the mountain limestone, or between the upper and the lower Carboniferous limestones.

The upper beds are two in number, and have been found of workable thickness; the lower beds are generally three in number, though they frequently develop more numerously. The "whin sill" is between the two series of seams, but far enough from either to prevent a coking or charring influence.

Those seams form a valuable body of coal at Scremerston, in the vicinity of Holy Island, some 30 miles from the extremity of the Northern coal-field, on the Coquet. Here this lower coal has developed to a thickness of 90 feet; and it is generally believed that the coal of the Lothians, in Scotland, still farther north, is of the same formation. Another basin of the lower coal series is found at Plasketts, to the west; while still west of that are the coals of Canobie, supposed to belong to the true coal measures.

The dip of the measures, generally, is from east to west in the Northern coal-field. They rise from beneath the sea towards the west at the rate of one in forty, or something over 100 feet to the mile. In the deepest parts of the basin the coal appears to be thinner than towards the outcrops, which seems to be the rule all the world over, viz.: in all very deep basins. The magnesian limestone lies over the deepest portions; but we cannot suppose that had any effect on the coal, which must have been formed long before the limestone.

COAL-SEAMS.

There are 57 seams of coal in the Great Northern field, from one to six feet in thickness, averaging 75 feet of coal; of these, ten are workable seams, from 30 inches to six feet thick, with an average working thickness of 40 feet; which leaves 35 feet of coal in seams not now considered unworkable, ranging from one to two and two and a half feet in thickness; a fact which it might be well to remember in any consideration of the duration of the British coal-fields.

The working seams are locally named, and some confusion exists in identifying them in different portions of the field. Those generally accepted in the Newcastle District are the High Main, Five-Quarters, Main Coal, Bensham, Hutton, Beaumont, Stone-Coal, Low Five-Quarters, Yard, or Three-Quarters, and the Brockwell.

We give a section of the High Main and Low Main in their most favorable condition. But accompanying will be found the variations of these seams at different localities, which will apply generally to all the other seams, since they change in about the same proportion.

FIG. 18.

HIGH AND LOW MAIN SEAMS.

High Main.

	Feet.	Inches.
Good coal	4	0
Band		6
Coarse coal	1	6
	6	0

Low Main.

	Feet.	Inches.
Jet, or cannel coal	0	6
Good coal	5	0
Bony or coarse coal	1	0
	6	6

Those seams are represented above in their best condition; below we give them as found under variable conditions.

High Main Seam.

		Feet.	Inches.		
Burdon Colliery.—	Coal	2	7½		
	Band		3½		
	Coal	3	0	5	11
Backworth's Pit.—	Gray metal	0	2		
	Poor coal	1	9		
	Gray metal	0	5		
	Coarse coal	2	5	4	9
Benton Pit.—	Coal, good	6	6		
	Undermining	0	6		
	Coal, coarse	1	2	8	2

Low Main Seam.

		Feet.	Inches.		
At Burdon Colliery.—	Coal	1	8		
	Band	0	2½		
	Coal	0	10		
	Blue-stone	0	8		
	Coal	2	6½	5	6
At Blackworth's Pit.—	Cannel coal—jet	0	2		
	Splint	0	3		
	Coal	2	1½	2	5½
At Benton Pit.—	Splint	1	3		
	Coal	5	1		
	Slaty coal	0	7	5	11

Average Thickness of Seams.

	Feet.	Inches.
High Main	6	0
Five-Quarters, or Metal	3	6
Main Coal, or Wear	4	6
Bensham, or Maudlin	4	0
Hutton, or Low Main	4	6
Beaumont	3	6
Stone-coal	2	6
Low Five-Quarters	3	6
Three-Quarters	3	6
Brockwell Seam	4	6
Total Workable Coal	40	0

But to this may be added 25 feet of coal existing in seams from one foot to two feet, or from 12 to 28 inches, in thickness, which are not now considered workable, but which will be considered valuable long before the British coal-fields are exhausted.

Assuming only half the entire area of the Great Northern coal-field to be underlaid by those small seams, or but half the area productive, they would still yield 20,000,000 tons per annum for five hundred years.

It may be a question to many of our readers, whether seams as thin as 12 inches can be worked at all, and much less to profit. We will here present some facts from the actual workings in the East Somerset coal-field, where the seams are generally thin. Near Bath, in this coal-field, are seven seams whose aggregate thickness is 12 feet,—three of them from 12 to 16 inches, and four from 24 to 28 inches. They are worked extensively on the "long wall" system, at the following items of expense.

COST OF MINING COAL IN EAST SOMERSET.

	Thick Veins over 18 inches.		Thin Veins under 18 inches.	
	s.	*d.*	*s.*	*d.*
Mining	1	1	2	2
Hauling	0	8	1	2
Raising	0	3	0	3
Making roads	0	5½	0	6½
Dead work	0	7	0	7
Total per ton	3	0½	4	8½

It will be observed by the above table, which is from an interesting paper by G. C. Greenwell, in Vol. IV., North of England Institute of Mining Engineers, that the average cost of mining coal in the thin veins

of Somerset is less than one dollar per ton, and not much, if any thing, over the cost of mining coal in the great anthracite veins of Pennsylvania.

We may also compare it with the cost of mining coal in the Newcastle district, as given by the same author, from the average production of the Five-Quarters, Low Main, and Hutton seams.

COST OF MINING COAL AT NEWCASTLE.

	Shillings.	Pence.
Hewing and narrow work	1	10
Putting and helping up	0	4½
Deputy work	0	2
Making wagon-ways	0	2
Shift work	0	1½
Delivered on top—total per ton	2	8½

These charges do not appear to include machinery or cost outside, but the simple mining charges, or inside work.

The quantity of coal mined in East Somerset during 1855 was about 400,000 tons, or 150 tons to the hand for under-ground work. In the Newcastle district the amount of coal mined per head in 1854 was about 494 tons for under-ground work.

The amount of coal actually realized from an area containing by calculation 122,082 tons, was 108,703 tons, leaving only 13,379 tons in the mine as waste or fine coal, dirt, and pillars,—or only 10 per cent. of the whole.

ESTIMATED COST OF DELIVERING COAL ON BOARD IN THE NEWCASTLE COAL-FIELD.*

Common Coal.

	s.	d.
Rent or royalty	0	6
Delivering in cars	4	4
Freight	1	6
Interest	1	6
	5	6

Extra household coals, &c. are estimated to cost more than this amount. This is calculated over a period of 20 years, and includes profits. From the same author we find the value of coal at the pits during 1845 to be, in the Northern coal-field, 6*s.* 6*d.* per ton; in Cumberland, Yorkshire, and Staffordshire, 5*s.* 8*d.* per ton; in Lancashire, Cheshire, Shropshire, &c., 5*s.* 8*d.*; in Scotland, Ireland, and Wales, 5*s.* 8*d.* These estimates are the

* T. Y. Hall, Vol. II., North of England Institute of Mining Engineers.

valuation of the average production, but the above estimate of the cost on board is only on common bituminous coal. Extra household coal, and superior steam or gas coals, are estimated to cost one-third more.

TOTAL PRODUCTION.

The total production of the Great Northern coal-field, from the commencement of the coal-trade to 1861, is about 1,051,812,483 tons; and the amount still calculated as available in the workable or larger seams, 5,575,432,173 tons. This is exclusive of a large area of the coal-field where certain workable seams have not proved remunerative under present circumstances, being thin and in some places faulty; nor does it include the 25 feet of coal in veins below 30 inches in thickness, or the vast area under the sea, and has no reference to the lower coal series, which may or may not underlie the entire coal-field.

At 20,000,000 tons annual production, the Great Northern coal-field is estimated to last 256 years, without reference to doubtful or undeveloped portions. If we add the contingencies on which the British manufacturers may fall back, we do not see any particular need for alarm on the score of exhaustion for the next 500 years at least.

The coal-trade of this field is now in excess of 20,000,000 tons; but the general opinion is that the trade will not increase to a much greater extent, since over two-thirds of the field is owned or controlled by a few large companies or wealthy proprietors, who are now working with more regard than formerly to the economy of future production.

In order to control the trade and keep out small operators, a large "*dead rent*" is paid by some of the companies. Those companies have leases on productive coal lands running from 20 to 50 years, on which they pay a certain annual royalty as "dead-rent" in lieu of the coal which might be extracted, but which is not yet wanted. It is estimated that over $2,000,000 have already been paid in dead-rents on these leases.

We give below a list of the great companies, collieries, and individual owners as they existed in 1855, from a paper by T. Y. Hall, published in the transactions of the North of England Inst. of Mining Engineers.

The number of collieries is 136, with 200 working pits, and the number of firms and individual owners less than 80.

NAMES OF PROPRIETORS.	COLLIERIES.	
1. LADY F. A. VANE, Marchioness of Londonderry.	Seaham, Rainton, Pittington, Pensher, Old Durham, Lady Seaham, Antrim	7
2. EARL OF DURHAM.	Houghton-le-Spring, Littletown, Newbottle, Sherburn, Sherburn House, Shadforth, Lady Durham...........	7

3. HETTON COAL COMPANY. Messrs. Cochran, N. Wood, Philipson, Burrell, Dunn, Ex. of Armorer, Duncan, Smart, and others.	Hetton, Elemore, Eppleton near Houghton-le-Spring	3
4. NORTH HETTON COMPANY. Messrs. Wood, Philipson, Burrell, and others.	Kepier Grange, Moorsley, Seaton, Hetton, North Hazard Pit, Grangelow, Dunwell	6
5. HASWELL AND SHOTTEN COMPANY. Messrs. Clark, Taylor, Plumer, Maude, Laws, and Bell.	Haswell Pits, Shotton Grange, Ryhope New Pits.	
6. SOUTH HETTON COMPANY. Messrs. Forster, Walker, Burrell, Green, P. Forster, I. Forster, Percival Forster, and John Forster.	Hetton South Pits, South Hetton Murton Pits, South Hetton Kelloe Pits, Tremdon Grange	3
7. THORNLEY COMPANY. Messrs. T. Wood, Gully, Chayton, and Burrell.	Ludworth, Thornley, and Trimden	3
8. Messrs. J. Bowes, Hutt, N. Wood, and C. M. Palmer.	Marley Hill, Dipton, Pontop, Greencroft, Andrew's House, Norwood, Kibblesworth, Springwell, Crookbank, Killingworth, Seaton Burn, Burnopfield, Shipcote, Delight Pits, Peareth Old Pit.	
9. Nicholas Wood, Esq.	Tees, Wallsend, Blackboy, Coundon, Westerton, and Leasingthrone.	
10. Messrs. W. Blackett, N. Wood, Anderson, and Philipson.	Harton, St. Hilda, and Jarrow	3
11. Townley Stella Company, ex. for the late J. Buddle, T. Y. Hall, C. & A. Potter, and M. F. Dunn.	Townley, Stella, and Ryton	3
Messrs. Bell and partners, as follows: 12. Davidson, Stobart, Crawford & Co.	Lambton, Lumley, Houghhall, Belmont, Harraton, Southmoor, Shieldrow, Haughhail, Shincliffe, Washington, and Monk-Wearmouth.	
13. Joseph Pease, I. W. Pease, and Joseph Pease & Company.	Adalaide, Bowden Close, Elden, Headley Hope, Jobshill, East Roddymoor, St. Ellens, and Woodhouse Close.	

14. Robinson & Jackson.	Hartlepool West Dock Pits, Thenwick, Byersgreen, Crowtees, Coxhoe, West and Clarence Hetton, Enghall, Newfield, and Little Chilton.
15. Edward Richardson & Co.	Spittletongs, Medomsley, Eden, Derwent, Cresswell, Acorn Close, Castlepit, Langley, and Medomsley Old.
16. James Joicey.	Stanley East, Twizell, Tanfield East, Tanfield Lea, Beamish, Tanfield Moor, and Tanfield Moor South.
17. Messrs. Carr & partners.	Burraton, Cowpen, Hartley, Seghill, and Felling.
18. Messrs. J. Lamb, Potter & Co.	Cramlington.
19. Messrs. J. Lamb, W. W. Burdon, Barnes, executor of Thos. Straker.	Seaton Delaval.
20. Messrs. Davidson, Easton, W. Anderson, Stodart, Bates & Henderson.	Bedlington.

The foregoing proprietors occupy the largest portion of the coal-field, and represent two-thirds of the capital employed. The following firms occupy only a small portion each, and are considered small proprietors.

NAMES OF PROPRIETORS.	NAMES OF COLLIERIES.
1. Messrs. Taylor, Plummer & Co.	Holywell Old, Holywell New, East, and Earsdon.
2. Messrs. Taylor, Lamb & Waldie.	Backworth and West Cramlington.
3. " Lamb, Potter & Co., Trustees.	Wallbottle.
4. Messrs. Lash & Co.	Tyne Main and Friar's Goose.
5. " Fletcher & Sowerby.	Erby and Burnhope Flat.
6. " Bell & Hunter.	Framwellgate, near Durham.
7. " W. Hunter & Co.	Benton, near Newcastle.
8. " Hunt & Co.	Ouston and Urpeth.
9. " W. C. Curteis & Co.	Pelton, near Chester-le-Street.
10. " Consett Iron Co.	Conside Pits, Crook Hall, and Black Hall Pits.
11. " Elliott & Ashton.	Oxclose, Usworth, and Nettlesworth.
12. " Cook & Co.	Castle Eden Pit.
13. " Headleys.	Cragside and Homeside.
14. Executors of Messrs. Brandling.	Gosforth.

15. Messrs. Bell & Brandling.	Coxlodge
16. " Tyzack.	Edmonsley.
17. " Dalton, Johnson & Co.	Heaton.
18. " Easton, Anderson & Co.	Hepburn and Oakwellgate.
19. " J. B. Pearson & Co.	Heworth.
20. Mr. Ralph Dixon.	Kepier.
21. Messrs. Cookson & Co.	Mickley.
22. Mr. Skinner.	Marshall Green.
23. Burkinshaw's Trustees.	Netherton.
24. Messrs. Longridge.	Barrington.
25. " Burdon & Barkus.	Allerdean.
26. W. W. Burdon.	Team.
27. Messrs. C. Atwood & Co.	Black Pierce, Thornley, and Towlaw.
28. J. B. Blackett, M.P.	Wylam.
29. Messrs. Thos. Sowerby & Co.	Waldridge.
30. " Surtees & Co.	Whitworth.
31. Mr. Kirsop.	Wittonpark.
32. " John M. Ogden.	Whitwell.
33. Lord Howden & Co.	Wingate Grange.
34. Messrs. N. G. & F. D. Lambert.	Walker and Bebsido.
35. " J. & I. Harrison & Co.	Radcliffe.
36. " D. Burn, Hawthorn & Co.	Stanley West.
37. " Straker & Love.	Bitchburn, Brancepeth, and Willington.
38. " Bolckow & Vaughan.	Auckland West, Etherley New, Woodfield and Whitlee.
39. " Stobart & Backhouse.	Etherley Old and Bitchburn North.
40. Marquis of Bute's Executors.	Chopwell.
41. Messrs. Harrison, Carle, Lange & Co.	Ashington.
42. " Carr Bros.	Bell's Close.
43. Joseph Cowan.	Bladen Burn.
44. G. H. Ramsay.	Bladen Main.
45. Armstrong.	Evenwood.
46. W. H. Bell.	Sacriston.
47. Muschamp.	New Bitchburn.
48. Pratman's Trustees.	Butterknowle.
49. Messrs. Bell & Johnson.	Willington.
50. " Losh, Johnson & Co.	Tyne Main.
51. " Gooch & Co.	Lints.

We have named the foregoing parties and collieries as an interesting record to many of our old English miners, perhaps, more than to our readers generally. This list is for 1853–54. We have not been able to find one of later date. Some of the collieries are not named, but the number is set down. In 1855, Mr. Hunt, the statician, gives 273 collieries, but evidently means pits, and includes the small land-sale pits.

There is not an entire agreement in the calculations of Mr. Hunt and the resident engineers. From the best authorities generally, averaging the several estimates, we find the following results. In the Great Northern coal-field, about 28,000 men and boys under-ground produced 15,000,000 tons in 1854, or an average of about 500 tons per head. In Scotland, 22,000 men and boys under-ground produced 7,250,000, or about 311 tons per head. In North Wales, Lancashire, and Cheshire, 32,000 men and boys under-ground produced about 10,000,000 tons, or about 320 tons per head. In Belgium, 36,000 men, women, and boys produced about 6,000,000 tons, or about 166 tons per head.*

The coal production of Northumberland and Durham, or the Great Northern coal-field, during 1861, was 21,777,570 tons from 271 collieries; and the production of Great Britain during the same year was 83,635,214 tons.

SOUTH WALES ANTHRACITE COAL.

We have, perhaps, devoted more space to the Newcastle coals than would be prudent if we proposed a general description of the English coal-fields in detail; but such a course would be neither appropriate nor

FIG. 19.

SOUTH WALES ANTHRACITE COAL-FIELD.

In figure 19 we have given the coal measures in solid black, since it is impossible, with our present information, to identify the seams, or locate them even approximately, in so small a space.

desirable in a work essentially American and devoted to an exposition of our mineral resources.

We have dwelt at more length on the Great Northern coal-field than we shall on any other British or foreign coal-field, because it has an historical interest and stands first in the annals of the coal-trade, as it is first in production, importance, and development. We shall now glance briefly at

* We may have made a few errors in our description of the coals and coal-fields of England, since it is difficult to choose between conflicting statements, and our distance from the scene prevents us from detecting them. We console ourselves, however, with the reflection that English writers on American subjects, and particularly on American coal-fields, can claim no exception on this score. We can only hope our errors are less numerous.

some of the peculiar English coal-formations, which may possess more than ordinary interest to the general reader, and simply refer to others, before dismissing the subject for the present. Under the heads of ventilation and economic mining, we shall again have occasion to cite the examples of British mines and miners.

The South Wales coal-field lies on the northwest of the Bristol Channel, extending from St. Bride's Bay in the east to Pontypool in the west, a distance of 90 miles, with a maximum breadth of 60 miles. Its mean breadth is less than 20 miles; presenting a productive coal area of from 1000 to 1500 square miles. It is divided longitudinally by an axis parallel to its strike, and divided also into numerous intermediate basins, while the measures undulate both from east to west, and from north to south, though the representations of the field, across the axis from north to south, are generally in the form of two immense basins, as portrayed by our transverse section above.

The deepest part of the field is supposed to be 8000 feet; that is, through the coal measures to the conglomerate. The depth of this field has been stated as 12,000 feet; but this statement includes some of the rocks below the coal, such as the millstone grit and the Carboniferous limestone. Most of the mining has been done by drifts, to the present date, and but few shafts have been sunk to any great depth.

Twenty-three workable seams exist in the principal basins, averaging altogether 92 feet of coal: of these, 12 are from 3 to 9 feet in thickness, and 11 from 18 inches to 3 feet. Besides these, there are numerous smaller seams from 6 inches to 18 inches thick.

On the north side of the field the coal is anthracite in character, and resembles the anthracites of Pennsylvania, though generally containing more hydrogen or volatile matter; on the east, or northeast, the coal is semi-bituminous, and is used extensively, both raw and coked, in the blast-furnaces of the region.

On the south side the coal is of a bituminous character. The change from anthracite to semi-bituminous and bituminous is gradual, and much the same in its metamorphic phases as we find existing in the coal-fields of Pennsylvania. As a pure anthracite it is used raw, but with hot blast in the furnace; but as a semi-anthracite it can be used raw with *cold blast;* and it is stated that the best pig-iron made with mineral fuel in Wales is produced with raw anthracite and cold blast. As a semi-bituminous coal, it is coked generally before use in the furnace, but even this coal is frequently mixed, both raw and "coked anthracite" being used in the furnace together.

There are 16 thin seams of iron-stone interstratified with the coal; the general yield of this ore is not over 30 per cent. of metal in the furnace; but being carefully calcined, and both coal and ore being pro-

duced on the spot, at low prices, iron can be manufactured as cheap at the Great Dowlias, or Merthyr Works, as in any part of the world.

The iron-masters of Wales discover, however, that a certain percentage of the richer ores, even at a much higher cost, not only improves the make, but reduces the general cost.

The coal production of South Wales in 1854 was 8,550,270 tons: of this amount, only 1,000,000 tons were anthracite,—the total being the products of 245 collieries.

The analysis of South Wales coal shows a larger amount of bitumen than coals of the same name in Pennsylvania.

	Carbon.	Volatile matter.	Ashes.
Bituminous (average) Wales	75.00	22.50	2.50
Semi-bituminous "	79.00	14.00	7.00
" " "	82.00	14.50	3.50
Anthracite "	89.85	8.65	1.50
" "	91.50	7.50	1.50
" "	94.05	3.38	2.57
Anthracite of Pennsylvania, White Ash	95.00	2.50	2.50
" " " Red Ash	90.00	7.00	3.00

We do not consider, however, that much dependence can be placed on such analytical tables as we possess; they are generally compiled from a variety of sources, and are, therefore, not entitled to credence. The English and French chemists always produce a closer analysis than ours have done, as a rule. The coals tested by Clemson, Johnson, Jackson, and other American chemists, always produce, as a result, from 2 to 10 per cent. more residue than the same coals when analyzed by Mushet or Berthier. There is, also, much difference in the results obtained by individuals. The same samples of coal, analyzed by three or four different persons, would show widely different results. Therefore, unless we have a series of analytical tests by one competent person, but little dependence can be placed on our tables of the constituents of coal for practical purposes.

NORTH STAFFORDSHIRE COAL-FIELD.

This is a comparatively small midland coal-field, containing from 40,000 to 50,000 acres of coal area, and is distinguished from other basins in the district as "the Potteries."

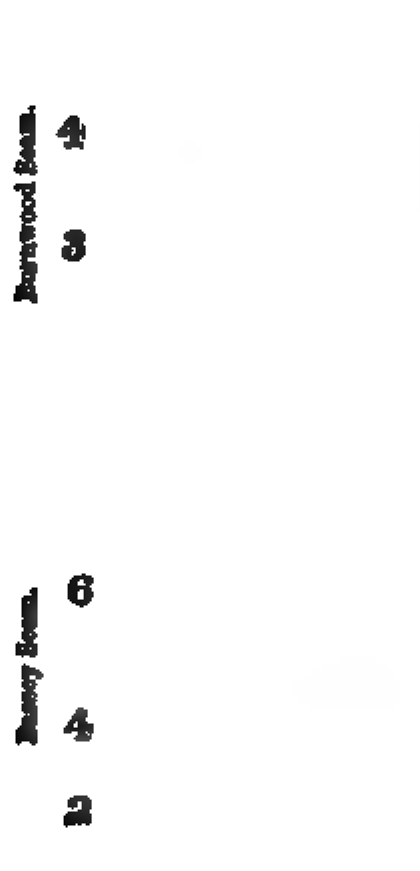
We notice it particularly on account of its supply of iron ores and fire-clays in connection with the coal-seams.

The basin is 2925 feet deep on the west side, and 5500 feet on the east side; it is covered by the new red sandstone in its central portions, which,

however, has not been developed, and the area not included in the above estimate. The aggregate or maximum thickness of the coal is 168 feet, and its average thickness, if distributed over the entire area, 32 feet. The maximum thickness of iron-stone is 23½ feet, and aggregate 5 feet.

The coal is distributed in 45 seams from 2 to 10 feet thick, and 8 seams from 6 inches to 18 inches thick.

Fig. 20.



IRON AND COAL-SEAMS OF NORTH STAFFORDSHIRE.

Burnwood Seam.

	Feet.	Inches.
Carbonaceous and argillaceous, nodular iron-stone	4	0
Coal, good	3	0
Band	0	9
Coarse coal	2	3
	10	0

Bassey Mine.

	Feet.	Inches.
Carbonaceous ore	4	0
Coarse coal	3	0
Fire-clay, *indefinite*	0	0
	7	0

There are several seams bearing iron-stone as the roof, besides those illustrated above, though generally smaller. It will be noticed, by those who are familiar with such matters, that this combination of coal and iron is eminently available for mining operations; and the consequent result is here practically manifest in the numerous successful furnaces which are in blast. The amount of iron-stone available in this district alone is enormous,—enough to supply the vast demand of the British manufacturers for 50 years.

The ore is peculiarly rich, producing double the yield of the Welsh ores. The average yield of metal in the furnace is over 50 per cent., while the best calcined carbonaceous will yield from 60 to 70; it is much used by puddlers to line their furnaces, and is there known as "puddle-mine." There is also a small seam of calcareous ore in the Carboniferous limestone, which is used in the furnace as a flux.

In 1853–4 there were 20 furnaces in blast and 5 in course of erection, &c. The production was 100,000 tons of pig-iron per annum. The coals on the east side of the basin are used raw in the furnaces, being free-burning and not liable to cake, while the coals of the west side are coked before used. The amount of coal consumed to the ton of pig-iron produced is 3 tons 14 cwt.

The primitive mode of mining was pursued to a late period, comparatively, in this district: the "post and stall," or "punch and thirl," was a favorite system with the old miners; but the cost of mining and the loss of coal in pillars forced improvements on them. By the old mode of mining, with coaves, water-buckets, &c., the cost of delivering coal on the bank was about 7*s.* 6*d.* per ton. By the recently adopted improvements and the general introduction of the "long wall" system of mining, the cost has been reduced to 3*s.* 4*d.* on the bank.

North Staffordshire is the great metropolis of the earthenware manufacturers, owing to the presence of immense beds of fire and potter's clay. Some of these beds are 45 feet thick, and of a fine-grained or impalpable texture. 50,000 tons of fire-clay are used annually for the "saggers" in which the ware is baked, and 800,000 tons of coal consumed in the operations at the potteries. The value of the goods produced is nearly $20,000,000 annually.

About 2,000,000 tons of coal is mined per annum in this district, mostly for home consumption, and 500,000 tons of iron-stone, of which about one-fourth is shipped to manufacturers outside of the district.

OTHER FOREIGN COAL-FIELDS.

We would like to extend this chapter with a notice of the large seams of South Staffordshire; but the space already devoted to the British coal-fields admonishes us that we must come to a close. The table given in the commencement of this chapter gives the area of coal formation, amount of coal in each field, number of seams, and maximum thickness of the largest seams; while in a previous chapter we gave the total production of the British coal-fields and the production of each field and district. A more lengthy and impartial description can scarcely be expected in a work devoted to American resources; and we here wish to be absolved from any charge of impartiality in the selections we have made, or the disappointment they may cause to a few of our readers who feel more interest in the great and valuable coal-fields of Scotland or the undeveloped coal-beds of Ireland, than in the productions of Newcastle or Wales.

COALS AND COAL-FIELDS OF FRANCE.

There are 62 coal-fields in France, but some of them are extremely limited and unproductive. The area of her productive coal-fields is 920 square miles, existing in 45 departments, and producing, in 1852, 4,934,196 tons of coal from about 500 collieries. The largest basins are those of the Loire, which produced 1,639,183 tons of the above amount, and the Nord, or Valenciennes,—a continuation of the Belgian coal-field,

—which produced 1,072,845 tons. The area of the first is about 50,000 acres, and of the second about 250,000 acres.

There are 134 workable coal-seams in the Valenciennes coal-field, or the department of Nord. But few of them are one mètre, or 3 feet 3½ inches, in thickness; most of the seams are 2 feet or less in diameter. In the basins of the Loire the seams vary in number and dimensions. In the district of the Rive-de-Gier are but three workable beds, with a total thickness of 32 feet; but in Saint-Etienne district there are 14 seams, with a total thickness of 114 feet; the seams, however, are subject to greater variation; they change suddenly and frequently from 6 or 10 feet to 60 or 90 feet, and *vice versâ*. In other districts seams of a remarkably thin character are worked. In the department of the Nord the 12 beds of Aniche are only 22 feet thick; and at Denin 4 seams have only 7½ feet of coal in the aggregate. But in the basins of Creuse and Blanzy, department of Saone et Loire, the thickness of the seams or beds is often enormous, and far greater than the expansions of our Mammoth, but more limited in extent of area. One of those large seams has a mean thickness of 40 feet, a maximum thickness of from 180 to 230 feet, and a prolongation on the surface of about 2000 feet. This great bed at Montchanin, where it dips at an angle of 40 degrees or over, is 230 feet thick at its outcrop. The depth of the basin is about 450 feet.

Coal seems to have been mined and used in France as early as 1321, and was imported from England in 1520; but not until 1787 was any large amount of coal used in that country. The home production of that year was 215,000 tons, and importation 214,378 tons, of which 154,378 was from England. For the yearly increase, see the accompanying table.

In 1852 there were 10,192 workmen employed in the mines of the Nord,—1612 above ground and 8580 below; they produced 1,072,845 tons of coal, or 105 tons to the hand, and their average annual wages amounted to £21 9*s.* per head, or about one hundred dollars a year to each man and boy. During the same year the number of men and boys in the department of the Loire was 6724, and the amount of coal produced 1,639,183 tons, or 244 tons per head; the average wages per head being £29, or less than 140 dollars a year.

The seams of the Nord are thin, as we have described, while those of the Noire are thick, which accounts for the great difference in production per head. The whole production of France, however, may be estimated between those extremes, though generally the production per head is nearer the lower than the higher figures, but the wages in some cases are from 16 to 20 English pounds sterling per annum.

PRODUCTION AND IMPORTATION OF COALS IN FRANCE.

Year.	Home Production.	Foreign Importation.				Total Home and Foreign Supply.
		Belgium.	England.	Prussia and Bavaria.	Other Countries.	
1787	215,000	50,000	154,878	10,000	......	429,878
1788	225,000	51,615	164,773	12,000	......	453,888
1789	240,000	50,000	180,000	10,000	......	480,000
1802	844,180	85,000	10,000	18,000	......	957,180
1811	773,694	95,000	French War.	25,000	......	893,694
1812	835,523	98,000	....	26,000	......	959,523
1813	771,779	90,500	....	27,000	......	886,779
1814	788,871	125,053	11,892	28,000	......	952,816
1815	881,587	198,462	22,482	28,500	......	1,130,981
1816	941,638	272,014	19,050	29,500	......	1,262,202
1817	1,003,380	192,742	15,775	50,334	......	1,262,231
1818	897,904	208,022	23,809	49,518	506	1,179,755
1819	964,009	170,045	23,991	42,359	371	1,200,775
1820	1,093,657	227,212	25,119	27,814	773	1,374,576
1821	1,134,711	251,801	31,105	38,524	168	1,456,304
1822	1,193,578	267,777	31,105	39,179	6	1,531,647
1823	1,195,227	264,878	23,282	38,704	106	1,522,553
1824	1,325,699	394,431	25,452	42,238	56	1,787,878
1825	1,491,581	439,248	26,684	42,393	292	2,000,199
1826	1,541,000	410,611	36,942	57,454	172	2,046,179
1827	1,691,075	423,224	47,780	70,825	184	2,233,091
1828	1,774,073	470,869	35,836	77,223	119	2,358,121
1829	1,741,570	435,947	42,848	75,612	21	2,295,955
1830	1,862,665	510,806	51,128	75,341	13	2,499,953
1831	1,760,385	443,549	35,911	68,924	23	2,308,792
1832	1,962,855	489,480	37,530	52,619	160	2,542,644
1833	2,057,631	580,171	42,640	79,185	250	2,759,980
1834	2,489,840	629,176	48,948	78,089	850	3,237,923
1835	2,566,416	615,157	98,159	89,738	24	3,309,491
1836	2,841,946	715,871	169,109	113,836	21	3,841,897
1837	2,980,735	788,413	222,005	132,678	184	4,124,138
1838	3,113,252	796,457	304,684	125,137	312	4,340,282
1839	2,994,861	740,810	310,527	156,918	750	4,203,604
1840	3,003,382	848,600	380,778	160,779	493	4,294,042
1841	3,410,199	990,225	429,949	196,502	506	5,029,358
1842	3,592,084	977,934	490,733	199,695	482	5,261,222
1843	3,692,539	991,860	455,662	213,014	815	5,355,226
1844	3,782,739	1,115,794	427,693	299,036	2,150	5,628,622
1845	4,202,091	1,396,166	560,748	240,498	3,360	6,406,282
1846	4,469,842	1,350,206	611,801	228,405	4,584	6,663,264
1847	5,153,204	1,686,990	586,520	272,330	4,009	7,701,924
1848	*4,000,433	1,399,880	514,920	227,090	2,880	6,146,208
1849	4,049,220	1,591,820	572,140	228,720	2,880	6,443,170
1850	4,433,570	1,953,190	602,410	277,280	1,770	7,266,880
1851	4,485,033	2,025,990	602,230	298,200	880	7,411,718
1852	4,903,925	2,119,180	652,890	324,260	260	7,999,885
1853	5,928,877	2,456,959	703,704	369,734	130	9,459,410
1854	6,827,707	2,856,146	780,449	492,989	136	10,956,995
1855	7,453,048	3,327,333	953,990	670,045	404	12,405,262
1856	7,740,317	3,119,630	1,165,878	3,781,521	2,970	12,810,316
1864	10,000,000	....	....	....	......	....

* Revolution of 1848.

PRODUCTION OF THE FRENCH COAL-FIELDS IN 1852.

Character of Coal.	Departments.	No. of Workmen.	No. of Mines.	Production.
Bituminous	Loire	6,724	70	1,639,18[illegible]
"	Gard	2,315	45	886,007
"	Aveyron	939	33	182.825
Anthracite	Isère	......	26	83,868
Bituminous	Herault	......	24	50,362
Lignite	Lower Alps	......	22	8,188
Bituminous	Saone and Loire	8.549	22	528,059
"	Nord	10,192	20	1,072,845
"	Mouth of Rhone	959	19	105,500
Anthracite	Upper Alps	......	17	4,720
Bituminous	Allier	2,365	15	256,467
Anthracite	Mayenne	915	10	85,480
Lignite	Var	......	10	469
Anthracite	Maine and Loire	......	9	48,877
"	Upper Loire	......	9	43,732
"	Upper Saone	968	8	56,966
"	Straits of Calais	......	8	87,069
"	Puy de Dome	......	8	29,766
"	Ardéche	......	7	15,359
"	Sarthe	......	6	28,038
Bituminous	Vosges	......	4	1,245
Lignite	Ain	......	4	457
"	Vaucluse	......	...	7,150
"	Aude	......	...	2,020
Bituminous	Creuse	......	25	4,820
"	Cantal	......	...	580
"	Vendée	......	...	12,290
Anthracite	Lower Loire	......	6	15,093
"	Corréze	......	...	5,899
"	Tarn	......	...	62,192
Lignite	Lower Rhine	......	...	10,210
Bituminous	Rhone	......	10	17,784
"	Drome	......	...	000
"	Finisterre	......	...	000
Anthracite	Calvados	......	...	24,906
Bituminous	Nièvre	625	...	78,934
"	Manche	......	...	000
"	Moselle	......	...	000
"	Yonne	......	...	000
"	Dordogne	......	11	000
"	Jura	......	...	000
"	The Two Sèvres	......	...	12,940
"	Doubs	......	...	000
"	Landes	......	...	000
Lignite	Eastern Pyrenees	......	...	200
			448	4,984,196

The entire production of 1856 is 7,740,000
And reported " " 1864 is 10,000,000

PRODUCTION OF IRON.

In 1852 there were about 75 blast furnaces in operation in France, which produced 522,643 tons of pig-iron, at a value of about $27.50 per ton. Of this amount, 263,340 tons were made with wood and charcoal, at a value of about $30 per ton, and 259,303 tons with coal and coke, at a value of about $25 per ton. About one ton of charcoal was consumed to the ton of metal produced, and about two tons of coal or coke.

During the same year 301,803 tons of malleable iron were produced, at a value of about $60 per ton; of this amount 64,601 tons were made with charcoal and 237,202 with coal and coke. The cost of fuel per ton of iron produced was about $30 for charcoal and $10 for coal and coke. About two tons of charcoal were used to produce each ton of malleable iron, and about three tons of coal or coke.

The data for the following tables are from a statistical paper by T. Y. Hall in Vol. IV. North of England Institute of Mining Engineers Transactions.

COAL AND COAL-MINES OF BELGIUM.

The Belgian coal-field is a long and comparatively narrow series of basins, extending about 75 miles from east to west, and lying in France and Belgium in about equal proportions, but narrower, and, consequently, longer, in the latter than the former country.

The portion in Belgium is 40 miles in extent from east to west, and 8 miles wide as a mean, with an area of 326 square miles of productive coal measures.

The number of developed seams is 114; but most of them are thin. The average is less than two feet, and but few are over three feet in thickness. Seams from 12 to 18 inches are considered workable; but the production is limited, considering the number of workpeople employed, in comparison with the production of the English mines. In 1850 there were 408 pits in operation, 159 idle, and 25 sinking; and the number, character, and wages of the workpeople were:—

	Below Ground.	Above Ground.	Above Wages.	Below Wages.
Men	28,471	7,531	*1.74	1.72
Boys	4,464	1,075	.65	.94
Women	2,274	1,771	.92	1.30
Girls	1,221	1,142	.56	.85

The total number of workpeople being 47,449, of whom 36,430 were employed below ground, and 11,519 above; the total production of coal during the same year being 5,820,588 tons, and the average production to

* 1 franc 74 centimes equal 0.33½ cents United States Currency.

each under-ground operative about 160 tons. The exports to France in 1850 were 1,953,190 tons; but in 1856 they had increased to 3,119,630 tons, and the annual home production increased in about the same proportion. It is reported that the production of Belgium for 1864 exceeds 10,000,000 tons.

The first engine erected in Belgium was in the Liége district, as early as 1723, for pumping water. In 1838 the hoisting-engines were 145 in number, with an aggregate of 3881 horse-power; the pumping-engines were 58 in number, with an aggregate of 5279 horse-power. In 1850 they had increased to 384 hoisting-engines, with an aggregate of 11,548 horse-power, and 143 pumping-engines, with an aggregate of 16,081 horse-power. The mining records of the kingdom give the following depths of the chief collieries in Belgium:—

47	pits	from	300 to 350 mètres*	in depth.
26	"	"	350 to 400	"
27	"	"	400 to 450	"
3	"	"	450 to 500	"
4	"	"	500 to 550	"

OTHER EUROPEAN COAL-FIELDS.

There are in Germany four prominent coal districts of the true or Carboniferous era, besides others in which lignite or coals of a more recent formation occur. The localities of the true coals are on the banks of the Rhine in Westphalia; on the Saar, a tributary of the Moselle, on the borders of France; in Bohemia and Silesia.

The Saarbruck coal-field, in Rhenish Bavaria, is an extensive and valuable basin, about 1000 square miles in area, with 103 beds or seams of coal varying from 18 inches to 15 feet in thickness. The Westphalia coal exists in a comparatively small basin, known as the Ruhrfort coal-field. Those two Prussian coal-fields produced in 1850, 2,750,000 tons; of which 781,521 tons were consumed in France, on whose borders those basins exist.

In Austria several coal-fields exist, but principally in Bohemia, Silesia, and Hungary. Of the coal-beds in Hungary little is known, and those of Silesia are still less developed. The quality is chiefly bituminous; the seams are few in number, but generally very thick. Anthracite exists to a limited extent.

The coal-basins of Bohemia are considered rich in coal, and mining is carried on to a considerable extent, chiefly for home consumption. More than 40 seams of coal are worked; while many more are known to exist. The workable seams are generally from 3 to 6 feet thick.

* A mètre is 3.28 feet, or a little over 3 feet 3 inches.

PART III.

CHAPTER VIII.

THE ANTHRACITE COAL-FIELDS OF PENNSYLVANIA.

Anthracite Coal-Basins—Comparative Value—Economy in Mining—The Wyoming or Northern Coal-Field—The Wyoming Valley—Its History in Miniature—Yankees and Pennamites—Massacre of Wyoming—General Topography of the Valley—Extent of the Coal-Field—Form and Features of the Basin—Sections of the Intermediate Basin—The Lackawanna Region—Carbondale District—Scranton District—Pittston District—Denudation—Wyoming Region—Wilkesbarre, Plymouth, and Nanticoke Districts—Baltimore Vein, or Monmouth—Grand Tunnel Vein, or Buck Mountain—Section at Nanticoke.

WE have now the most interesting portions of our work before us, and to ourselves and our country the most important. Perhaps of all mineral deposits the most valuable in this of in any other country is that which we propose to describe in the following pages.

The area and dimensions of the coal-basins composing these anthracite fields of Pennsylvania are comparatively small, when compared with some of the prominent coal-fields of Europe which we have just passed over, and insignificant when compared with our own great bituminous deposits west of the Alleghanies. But when we consider the immense and populous area depending on those fields for its supply, and their central location, we are led to reflect that present availability is of far more value than prospective developments, and particularly when those future resources are only susceptible of development through present means.

At this period of our country's history or existence, its anthracite coal-fields are invaluable; and were we forced to decide at the present moment on the relative value of the bituminous and anthracite coals within our territory, it would undoubtedly be in favor of the 470 square miles of the one, against the 200,000 square miles of the other; not that we would undervalue our bituminous coals, the immense and incalculable value of which is more a matter for the future than the present: yet it may not be a long period before the Western deposits will equal the production of the Eastern basins.

More depends on the localities of coal-basins than on their extent. The anthracite beds are in the midst of a populous region, in the vicinity of many great and wealthy cities, and are surrounded by manufacturing

establishments, which are rapidly growing and prospering on the wealth which is developed around them.

Twelve millions of inhabitants derive their chief supply of coal from these fields, and will continue to do so until they are to a great extent exhausted. But before that time arrives, those 12,000,000 of inhabitants will have increased to over 30,000,000, and the present production of coal will increase perhaps in a double proportion. The area which the coals of Pennsylvania will naturally supply is over 300,000 square miles, or more than double the area of Great Britain, which now contains about 30,000,000 inhabitants and produces nearly 100,000,000 tons of coal. The area which must be supplied with anthracite coal is susceptible of sustaining a population as dense as that of Great Britain, and their manufacturing and commercial pursuits will demand an equal amount of coal per head. That this demand must be chiefly supplied from the anthracite regions is evident from the fact of proximity and the availability and cheapness of the fuel produced. That much of the semi-bituminous and bituminous coals will be used there can be no doubt; but since the anthracite has proved a superior fuel for most purposes, and as it can be mined with equal facility or expense, it is not probable that the distant bituminous will be used while the present anthracite lasts.

At present, we do not value our anthracite lands at a fraction of their real worth; but the time will come when they will be held as a monopoly, and their fortunate owners will derive revenues from rents that might now be considered visionary even to name. Coal lands sell now in the anthracite regions from $150 to $1000 per acre. The same lands will not be bought, twenty years hence, for five hundred per cent. addition. The coal lands of England, in the older or more developed regions, command from $5000 to $7000 per acre, but they seldom change hands. Yet the rents paid by the miners or operators there, when they lease from the proprietors, do not exceed 12 or 15 cents per ton. There, 35 feet of coal is all that is credited as workable or available for present use; here, 60 feet of coal is the average, and from 25 to 50 cents per ton is demanded. There, 750 square miles of area produce 21,000,000 tons of coal per annum, with but little prospect of a much greater increase; here, 470 square miles of area produce 10,000,000 tons annually, with a positive certainty of a rapid and vast increase. It therefore takes but little calculation to estimate the relative value of coal lands in the anthracite regions of Pennsylvania, or the bituminous districts of the Great Northern coal-fields of England,—particularly when *this* is a monopoly beyond competition from other fields; while *that* is in active competition with numerous surrounding coal-fields, where coal equally good and equally cheap is produced in abundance.

We have not chosen, perhaps, the best words, or the most striking

examples, to demonstrate the value of our coal deposits; but that is a small matter in comparison with the degree of economy with which we should preserve and utilize the invaluable stores of mineral wealth which those fields contain.

We have noticed that all our old or primitive miners did their work in a primitive manner; that in all new regions where coal is plentiful, the easiest way is always the first way, though it may be the most expensive in the end.

For many years, in the early development of the English mines, the waste or loss of coal in refuse, pillars, and "lost mine," was equal to our present enormous waste,—say 50 per cent. But improvement, care, and economy have reduced the 50 per cent. to from 10 to 15 per cent. in the English mines.

Such a consummation is most desirable here, and, we think, attainable under a proper system of mining,—ultimately attended with far greater economy than our present system, though, perhaps, more expensive to establish.

Our present production of merchantable coal is over 10,000,000 tons, but the present annual drain on our resources is over 15,000,000 tons. Our loss is now 5,000,000 tons annually. But we may not look far in advance to see those figures doubled; and our dead loss will then begin to be noticed and appreciated.

If we estimate the *dead loss* at 20 per cent. under such a system as might be inaugurated, instead of 50 per cent. as now suffered, the saving to individuals, community, and country would be great.

It would cause a direct gain of 6,000,000 tons per annum on a production of 20,000,000, and might be obtained without one cent of additional cost per ton to the miner or operator, except in rents to the landed proprietors. This, we presume, they would appreciate, if our miners should not; but they, too, would find this economy profitable. Instead of a "lift" lasting 10 years under a waste of 50 per cent., it would last 13 years under a waste of only 20 per cent., and 1,300,000 tons of coal would be obtained instead of 1,000,000; while the cost of pumping, raising, superintendence, &c. would be about the same.

In that portion of this work devoted to the Economy of Mining, all the information attainable on this subject will be found; and we hope to demonstrate the practicability of saving a larger percentage of our present enormous waste than here intimated.

In describing the respective coal-fields of the anthracite regions, we shall follow the plan adopted in the preceding pages, and commence with Wyoming. Its early history, magnificent extent, fame, and natural beauty, all conspire to give this rich and lovely valley pre-eminence in an

historical point of view; while its coal-trade and mineral resources place it first among the anthracite fields.

We must here object to a misnomer which has lately been growing into use by writers and the public generally. We notice the "Great Northern or Wyoming coal-field" mentioned as the "Lackawanna coal-field" in two late publications; one being an elaborate paper published in the Transactions of the North of England Institute of Mining Engineers for 1864, and the other a Hand-Book of the New Jersey Central Railroad, published in a neat and handsome style by the Messrs. Harper. The Lackawanna district or region is simply one end or portion of the field, as a glance at any map of the anthracite coal-fields will show. It is important on account of its greater development and production, but the larger portion of the coal lies in the Wyoming Valley proper.

It is a singular distinction which names the lower end of this great coal-field, or valley, Newport, and the upper end Lackawanna, since there is no termination to the great mountain-ranges forming alike the valley and the coal-basin, from the extremity of Newport to the end of the Lackawanna; and when we speak of the valley, generally, we call it the Wyoming Valley. We therefore object to this misnomer, which rejects a proper name, old and honored, for the name of a simple district which has no application to the coal-field generally.

THE WYOMING VALLEY.

We cannot fairly introduce this interesting coal-field to our readers without giving a brief resumé of the eventful and romantic history of the Wyoming Valley.

When the white man first visited this paradise of the Indian hunter, the Delawares held sway over the region, though under subjection to the more powerful Iroquois. Had it not been for the petty wars which constantly imbrued the hatchet of the aborigines, and made warriors of those children of the forest, Wyoming might have been almost an Eden to the red men.

No river ever abounded with finer fish than those which stocked the Susquehanna, and no forest ever afforded the hunter finer game than the mountains of Wyoming; while the "great plains" returned abundant harvests to the labor of the squaws.

But this fruitful and delightful vale was ever a coveted possession. First the wild Indian disputed the prize in a hundred battles, and subsequently the white men, in spite of king or council, struggled long and desperately with each other for this gem among the mountains of the "West."

The Nanticokes have left their fame engraven on the rocks of their country, as imperishable as the land itself, and the Shawnees have their

monument in the mountain which bears their name, while the noble Delawares—the Leni-Lenape—leave their legends with stream and vale and hill. But still farther, in the remote past, before the existence of the red man's traditional history, Wyoming was peopled by superior races, who left behind them mounds and walls and the relics of a civilization which the savages never possessed. The same race existed here which have left their mysterious story in the unriddled mounds of the West,—a people more civilized and conversant with the arts and mechanical skill than our painted ancestors of Britain, or many of the semi-civilized nations of to-day.

THE PENNAMITE WAR.

A word now in relation to the feuds and wars of the white man for the possession of Wyoming. On the 3d of November, 1620, James I. of England granted to the "Plymouth Company" all the territory lying between the fortieth and forty-sixth degrees of north latitude, and from the *Atlantic to the Pacific Ocean.* The charter of the State of Connecticut was derived from this Plymouth Company. It covered *all* the land west of Connecticut, one degree in breadth, from "sea to sea," and consequently included a large portion of Pennsylvania, and particularly the Wyoming Valley.

About fifty years after this event, the British crown granted to William Penn the province of Pennsylvania, and, singularly enough, one degree of latitude from the second east to the fourth degree west longitude, or an area of one degree of latitude and six of longitude, lay within the Connecticut or Plymouth grant.

Both parties subsequently bought the land from the aborigines,—William Penn from the Delawares, who were in possession by sufferance from their conquerors, the Six Nations, and the "Susquehanna Company," formed for the purpose of settling the Wyoming Valley, from the Six Nations themselves. Penn afterwards bought it again from the Six Nations.

As early as 1750 a few daring adventurers from New England had penetrated the then western wilds as far as the mountains of the Susquehanna, and saw for the first time the lovely Valley of Wyoming, the most beautiful landscape the eye can behold.

When the adventurers returned to the rocky hills of Connecticut, they told the most wonderful tales of a "paradise" which lay among the Western mountains. Others, doubting, went to behold the scene for themselves, and came back with excited imaginations and glowing descriptions, which more than confirmed the reports of the first.

"The Susquehanna Company" was then formed in New England for the settlement of the land in Wyoming; the land was bought from the

Indians, and in 1762 about two hundred of the company removed to the valley; but late in the same year they were surprised by the Indians, and about 20 of their number massacred; the remainder fled, naked and hungry, through the inhospitable mountains to their former homes.

A few of the more daring and hardy settlers returned to the valley; but not until 1769 did any of the company return. By this time the valley had been taken possession of by the proprietors of Pennsylvania, and now ensued a long series of petty wars between the "Yankees" and the "Pennamites." Each laid claim to the valley, and both parties struggled for its possession with equal determination. From this period until the commencement of the Revolutionary War this civil strife raged, with varied success, but with much suffering, bloodshed, and intrigue. Three times were the Yankees dispossessed, and driven, destitute, over the mountains, back to New England; but as often did they return to repossess the fields which they valued so highly, and the vale which had so many charms and claims on their affections.

This strife between the "freeholders" of Connecticut and the great Pennsylvania land-monopoly, which was unpopular even in Pennsylvania, because they tried to inaugurate a "tenantry" or feudal system similar to the English, was not a mere question of titles or boundaries, or a simple case of ejectment between landlord and tenant. Wyoming was the battle-field where the question was settled that the people of Pennsylvania should be *freeholders*, instead of mere *serfs* or *tenants;* and in this strife, which was fought between the "Yankees," as they were called, and the landed proprietors, the former had all the sympathy of the Pennsylvania tenantry, while the latter became hated and were forced to abandon the tenantry system, and sell their lands to freeholders in fee-simple, instead of pursuing a system of leasage or life-rents.*

The Revolutionary War for a time suspended hostilities between the freeholders and the proprietaries; but before it was fairly over the proprietaries returned to the attack, and the hardships and sufferings of the settlers were less endurable under their remorseless avarice than under the barbarous cruelty of the tories and Indians during the dark hours of the War of Independence. We cannot follow the events; but at last the indignation of the people of Pennsylvania was aroused against the proprietors and their treatment of the Wyoming settlers, who had so manfully fought side by side with themselves for liberty, while oppressed by a monopoly which threatened their lands and homes; and the result was that the legislative Assembly of Pennsylvania, in 1784, "ordered that the settlers be restored to their possessions."

* Rev. George Peck's History of Wyoming.

THE MASSACRE OF WYOMING.

In the year 1778, when most of the able-bodied or young men of the valley were with Washington in the Continental army, a descent was made by the tories and Indians from Sir John Johnson's department in the north, under Col. John or "Indian Butler," on the defenceless inhabitants of Wyoming.

FIG. 21.

WYOMING MONUMENT.

The force consisted of about 400 British provincials (mostly tories) and 600 Indians. They came suddenly into the head of the valley about the 30th of June, and captured Fort Wintermoot and Fort Jenkins without opposition. But the people of the lower part gathered hastily into "Forty-Fort," and those who were able to bear arms immediately prepared to defend themselves and their families. About three hundred men and boys were under arms, and divided into six companies, under the command of Col. Zebulon Butler, a brave Continental officer. Instead of awaiting the attack of the enemy behind such defences as they had constructed or might construct, it was determined, against the advice of Col. Z. Butler, to advance immediately against the foe. Accordingly on the 3d of July these 300 raw militia advanced against 1000 well-armed soldiers and experienced warriors on the open field. At first the British line gave way before the firm and steady advance of the yeomen of Wyoming; and had Indian Butler had no more than his 400 tories, he would have been put to disastrous rout. But the Indians fought from stump and tree, and flanked the American left so far that it became necessary to stop the advance, and form the face of the left flank against the flanking Indians and at right angles to the main line. In attempting this manœuvre, the militia became confused, and the red warriors rushed on them in overwhelming numbers, and thus the day was lost. About 160 of the Connecticut people were killed in battle, and about 40 more were murdered after surrender or whilst being pursued. Indian Butler reported that he had taken 227 scalps and only 5 prisoners. On the surrender of the fort the following day, with the remnant of the patriot band, it was stipulated that "the citizens should occupy their farms peaceably, and that their lives and property should be preserved." But the Indian allies of the British could not be restrained, or Indian Butler did not try to restrain them, and the result was that murder and robbery held high and diabolical sway while means were left to gratify savage propensities.

The inhabitants fled, and the valley was again deserted and silent,—left to the torch of the red demons; and only late in the fall did the settlers dare to return to bury the remains of their brave comrades who fell.

Forty-Fort was about three miles from Kingston, and the battle-ground, where the monument now stands, near the village of Troy, about five miles from Kingston.

Many of the early newspaper stories of this bloody affair—bad as it really was, and deserving of condemnation for all time—are mere fabrications, or the wild reports of frightened and distempered minds. There was no indiscriminate massacre of women and children after the surrender, or cold-blooded slaughter of captive soldiers. All the soldiers who survived the battle and pursuit found their way out of the valley, and most of the women and children were allowed to escape. A few who lingered near their homes were killed and scalped, and the homesteads of the settlers were generally given to the torch, and all their horses, cattle, and movable property were carried off as plunder.

But the savages paid dearly for their short-lived triumph. During the following year, Gen. Sullivan passed through their villages like an avenging angel, destroying, with fire and sword, warrior and wigwam, corn-field and council lodge. For a full month an army of 4000 men were busy in accomplishing the destruction, and from Wyalusing to the Seneca and Cayuga Lakes every hut and wigwam was given to the flames. At one Indian town, fifteen hundred peach-trees, bending under their load of ripening fruit, were hewn down by the fell axe of the destroyer. Did the Indian traditions and misfortunes live in history in comparison with ours, it is a question on which side would lie the heaviest account. But this does not justify the actions of a Christian nation, who paid the bloodthirsty savage, ever burning for revenge, a price for white scalps indiscriminately,—whether taken from the yeoman in battle or from the innocent occupants of some peaceful cabin in the dead of night.

GENERAL TOPOGRAPHY OF THE VALLEY.

From Prospect Rock, overlooking the valley from the rear of Wilkesbarre, a fine view is presented. The plains and hills on each side of the river spread out like a picture below, dotted with town and village, colliery and farm; diversified with grove and homestead, swelling hills and gentle dales, and animated by the moving panorama of a busy multitude. Here now rushes the iron horse along his shining track; there creep the boatmen along their silvery path; and on every side arises the steam of the laboring engines which draw from beneath those attractive scenes the hidden wealth which makes Wyoming, perhaps, the richest valley under the sun.

The scene from Prospect Rock is given in a former chapter, in connection with our account of the discovery and use of coal in the valley. Below we give a view of Campbell's Ledge, opposite Pittston, which not only commands a fine prospect both down the valley proper and up the Lackawanna, but is in itself a picturesque object, and offers a good exposition of the formation of the rocks underlying the coal measures.

CAMPBELL'S LEDGE.

At the foot of Campbell's Ledge, the Susquehanna breaks through the huge Shawnee Mountain from the north, and glides gracefully, with a

sweeping curve, into the valley. Here it is met by the tawny waters of the Lackawanna, which—pretentious stream as it is—scarcely swells the volume of the noble river. From this point the Susquehanna meanders lingeringly down the vale to Nanticoke, some 18 miles from where it enters; and here it leaves the valley again, breaking through the mountain barrier on the same side it entered.

From Nanticoke the river runs parallel with the coal-field, a short distance to the right, and in the soft red shales underlying the conglomerate, some nine miles, to Shickshenny, and here again, for the last time, crosses the extremity of the coal-field. But here the outcropping coal, which lie over a thousand feet below the bed of the river at Nanticoke, is two hundred feet above it.

The Lackawanna comes down from the east through the upper portion of the coal-field and joins the Susquehanna at Pittston, or the foot of Campbell's Ledge, as mentioned above,—traversing a distance of about 25 miles.

The mountains enclosing the great valley, or basin, are parallel for a distance of 50 miles, and distant, from crest to crest, about four miles; but at each extremity they meet or terminate. On the northern side runs the Shawnee range, and on the south is the Wyoming Mountain: the Wyoming Valley, therefore, is the proper name for the entire basin. The Lackawanna seems to be a misnomer as a general cognomen, though locally applicable as the bed of the stream; while the use of Lackawanna instead of Wyoming, as a distinctive name for the northern anthracite coal-field, is unwarrantable.

THE THIRD, NORTHERN, OR WYOMING ANTHRACITE COAL-FIELD.

This is the largest of the anthracite basins of Pennsylvania. The latest and, we think, the most reliable computation gives it an area of 198 square miles, or 126,720 acres. Its length is over 50 miles from a point opposite Beach Grove, which is a short distance below Shickshenny, to a point some five or six miles east or northeast of Carbondale. Its maximum breadth is over five miles, and its mean not less than 3¾, or nearly four miles.

The general form of the field is that of a long, narrow, trough-like basin, deep at its lower or western extremity and shallow at its upper or eastern end. It is not, however, straight, or perfectly parallel along the lines of its axis, or strike, but has a gradual curve from end to end, in the form of a crescent or slightly-bended bow, curving on a radius of about 50 degrees,—the eastern horn pointing at Carbondale N. 20 degrees E., and the western horn at Shickshenny, S. 20 degrees S. of W. At both extremities the coal measures rise gradually to a point far above water-level on their central depressions, in like manner as they rise along the sides of

the basin, but with comparatively low ascending angles. It is therefore emphatically a basin, with a rim of hard and durable conglomerate, ranging from 100 to 300 feet thick.

It contains in an eminent degree all the conditions necessary to the production of coal; and, judging from present appearances, we might be tempted to state it as an independent formation, having no reference to or cotemporaneous existence with any other coal-field, and without relation to the great Appalachian formation; but a general knowledge of the cotemporaneous geology, of course, permits no such inferences. There can be no doubt, however, of the fact that the basin in which this coal-field now lies existed as a basin or deep lake, not only when the coal was formed, but long anterior; and the probability is that but little if any coal was ever formed on the surrounding mountains. Coal was originally formed in basins, and always exists in basins; and wherever the conglomerate presents evidence of the existence of a basin, there coal is always found. There are many cases of denudation, but they leave their evidences behind. Basins may be cut through in a hundred places by water, but there are always portions of the formation left.

Below we present a view of Shickshenny, and on the next page a general illustration of the Wyoming or northern coal-field. It presents at a glance the whole geology and peculiarities of the basin.

SHICKSHENNY.

The accompanying illustration presents the plan or area of the coal-field; the form or lay of the coal measures lengthwise, or from east to west, and the form of the intermediate basins, or the cross-sections from north to south.

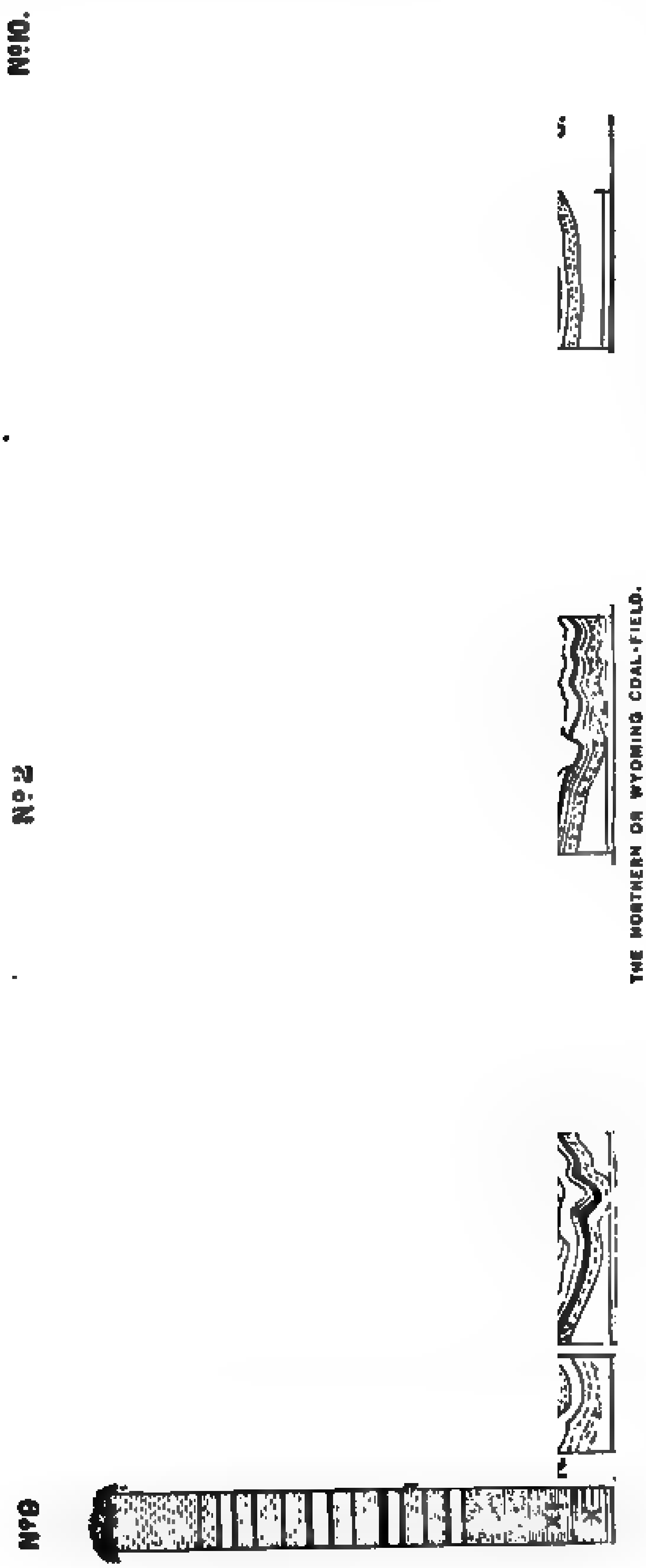


Fig. 22.

No. 1 is the plan or general superficial form of the field or basin. *C*, at the eastern end, is the location of Carbondale; *S* represents Scranton, and *P* the position of Pittston. Here the Susquehanna breaks through the Shawanee Mountains and enters the valley, and here the Lackawanna, rising above Carbondale, and running by Scranton, joins the river. About nine miles below Pittston is the location of Wilkesbarre, represented by *W*, and opposite, on the line of the Bloomsburg & Lackawanna Railroad, is Kingston, *K*. A short distance below is Plymouth, nearly opposite to the Nanticoke Railroad, and the plains leading over the mountains from the Valley of the Susquehanna to the Lehigh, and connecting with the Lehigh & Susquehanna Railroad.

Below *PI*, at *N*, is the location of Nanticoke, where the Susquehanna again breaks through the Shawanee Mountains and leaves the valley. About nine miles to the west of Nanticoke is Shickshenny, outside of the coal-field and near its western extremity. Here the river again sweeps to the south and crosses the point of the basin, but here the bed of the river is from one hundred to two hundred feet below the coal measures, as represented in the longitudinal section of the formation.

No. 2 is a longitudinal section of the coal measures from east to west, following closely the plan or surface as given in

No. 1, immediately below. In the background are the Shawanee Mountains, and the gaps through which the river enters and leaves the valley. The dark lines represent the coal measures, which lie deep in the lowest parts of the basin, and rise nearly to the summit of the mountains at each end. The deepest part of the basin is below Wilkesbarre, and nearly opposite Plymouth, while the deepest portions of the basin generally lie between Pittston and Nanticoke, or still farther to the west of Nanticoke. From Nanticoke, however, the measures commence to ascend to the west, as at Wilkesbarre they ascend to the east. In the vicinity of Pittston they are as near the surface, or as shallow, as at any point between the extremities of Carbondale and Nanticoke, and the undulations are here more irregular and uncertain than in any other part of the field. The dip is to every point of the compass, while the general rule or angle of dip is north and south, and the strike of the axis from east to west. Above Pittston the measures become more regular, and frequently run deeper, but they are still shallow compared with the deep basins below Wilkesbarre. In the vicinity of Scranton the total thickness of the coal measures is about 500 feet, and we presume the deepest basins above Pittston will not be over 800 feet, while in the district below Wilkesbarre they are from 1000 to 1500 or perhaps 2000 feet deep.

Transverse sections, Nos. 3, 4, 5, 6, 7, and 8, represent the dips and intermediate basins of coal at different points across the field.

No. 3 represents the basin at Carbondale, its eastern extremity, where the angles are low and the coal comparatively near the surface. Here the upper seams or veins do not exist, and only one or two of the lower ones are found in a workable condition; but generally the veins are productive, easily mined, and the coal is good.

No. 4 represents a cross-section at Scranton, where the measures are more regular than they are farther west, and perhaps less deep than at certain points farther east; while the angles of dip are more uniform and low. The angles of dip vary considerably, but may be stated as a mean between 8° and 10°.

No. 5 is a section across the field at Pittston, east of the point where the Susquehanna enters the valley. The undulations on the south side of the Lackawanna are very irregular and uncertain; the dips are to all points of the compass, and the basins comparatively shallow. On the north side of the Lackawanna there has been but little development made, but the measures are more regular, and have a general inclination from the top of the mountain east of Campbell's Ledge down to the Lackawanna, with an angle of about 5°. This low and uniform angle varying from 5° to 12° is general along the northern edge of the basin, except at a few points; one of these is behind West Pittston, and another below Shickshenny, as shown in No. 8.

No. 6 represents a transverse section in the vicinity of Wilkesbarre. The section is too small to portray correctly the basins and angles, but conveys a general impression of the undulations. We will give, farther on, a more correct delineation. The same general features are noticeable here as at Pittston. The undulations are greater on the southern than the northern edge of the field. In fact, the angles of dip beneath the Wyoming Mountain are much greater here than at Pittston, but the axes are regular, running east and west, and the dips more uniformly north and south.

No. 7 is a cross-section below Nanticoke, and represents some of the sharpest or most abrupt angles of dip found in the valley, with the exception perhaps of a few localities to the south and southwest of Wilkesbarre, along the outcrops of the Monmouth, at the immediate foot of the Wyoming Mountain, and along the "Hogback," which is a ridge running from a point below Nanticoke nearly to Wilkesbarre, and in which the veins rise nearly perpendicular.

No. 9 is a vertical section in the vicinity of Nanticoke, and No. 10 is a vertical section of the coal measures near Scranton. We give these to present a comparison of the depth of the measures at these respective points, and the relative position and number of veins. Farther on will be found more elaborate sections.

With the aid of the foregoing description, and the accompanying

illustrations, we hope a good general impression of the form and features of the Wyoming Valley and basin may be obtained.

A great portion of the coal of the northern field is accessible by shallow shafting,—perhaps two-thirds of the entire amount. All the coal above or east of Pittston, and fully one-half below, or west, can be obtained within an average shafting depth of 400 to 500 feet, or within 800 feet as a maximum. This may be considered as eminently available, when compared with many of the European coal-fields, or as compared with the greater portion of the deep coals of Schuylkill county.

But little of the Wyoming or Lackawanna coals, however, can be obtained by drifting above water-level, though much of the coal on either edge of the basin really exists above it. The conformation is such that the coal is not accessible by drifting on the strike of the veins, since they are not often exposed across the axis; the inclination of the covering strata being parallel or on a plane with the coal, and the form of the valley conforms to the shape of the coal-basin beneath. Therefore, the coal which lies above water-level can only be reached by long tunnels or short shafts. There are notable exceptions, however, as may be found at Nanticoke and the western extremity generally, though but little developed; at the old Baltimore mines, and on the property of John T. Everhart, northeast of Pittston, the same facilities exist for mining above water-level. But generally, as we before observed, most of the coals of the northern field are more accessible by shafting than by any other mode. We include slopes, which are but inclining shafts, in the same category; though this mode is only available at a few localities in the vicinity of and below Wilkesbarre.

The accompanying columnar or vertical sections, through the coal measures, at three different points in the basin, will enable us to present several interesting subjects in connection with the veins and the measures in a clear and definite form. They show the relative depth of the basin at the points distinguished; the sizes and number of veins; the order of their existence or position, and their identity,—which, we believe, has never before been attempted.

THE LACKAWANNA REGION.—CARBONDALE DISTRICT.

The accompanying section, Fig. 23, shows the depth of the coal measures at Carbondale, the number of veins, and the thickness of coal which they contain. The figures represent feet; those in the body of the column, the thickness of the intervening slates and sandstones, and those on the left, under the letters, the thickness of the respective veins opposite. The letters are chosen to distinguish the veins, instead of the names, which change with every locality. We shall thus be enabled to

prevent confusion, and always represent the same bed by the same character wherever found. E is the fifth vein from the conglomerate, as a general rule, in every part of each anthracite field. There is but little variation from this rule, and none where the seams are regular and not divided.

Fig. 23.

VERTICAL SECTION AT CARBONDALE.

At this point,—that is, near the eastern extremity of the Lackawanna region,—the lower veins do not develop in workable dimensions, and D is, perhaps, the lowest workable bed developed. E is the great Carbondale bed, seam, or vein, and is synonymous with the Scranton G vein, the Pittston 14 feet, the Baltimore vein at Wilkesbarre, and the Mammoth vein in the Schuylkill region.

Vein F is generally small in all the anthracite regions, varying from 3 to 6 feet.

We presume the sizes here given to be the maximum dimensions of the Carbondale seams. There is some doubt of the existence of F in this portion of the region, and F here is what we have elsewhere given as G, or the Scranton E vein, which it nearly represents. The amount of workable coal in this section is about 20 feet. Lower down the Lackawanna, at Archibald, Olyphant, and Providence, the veins are more numerous, and the measures deeper, but we do not find E at any point in this region larger than at Carbondale. This fact suggests the inference that veins E and D are here included in the 24 feet of vein E, as given. It is very difficult to commence the identity at this point, since the measures, which at Scranton are from 500 to 700 feet thick, are here only 150 to 200 feet in thickness; and consequently, the veins are thrown closer together. We may, therefore, be safe in stating that the veins which we give as E and F are identical with the Scranton veins locally named E, G, and H, and with those on our section of the Scranton district, named D, E, and G.

Fig. 24.

CARBONDALE BED, OR MAMMOTH VEIN, E.

We give below the size and character of the Carbondale bed, with its bone, slate, and partings; premising, however, that we believe it to be a combination of our Mammoth and Skidmore, or veins D and E of our nomenclature, or perhaps F, E, D, and C.

SCRANTON DISTRICT OF THE LACKAWANNA COAL-REGION.

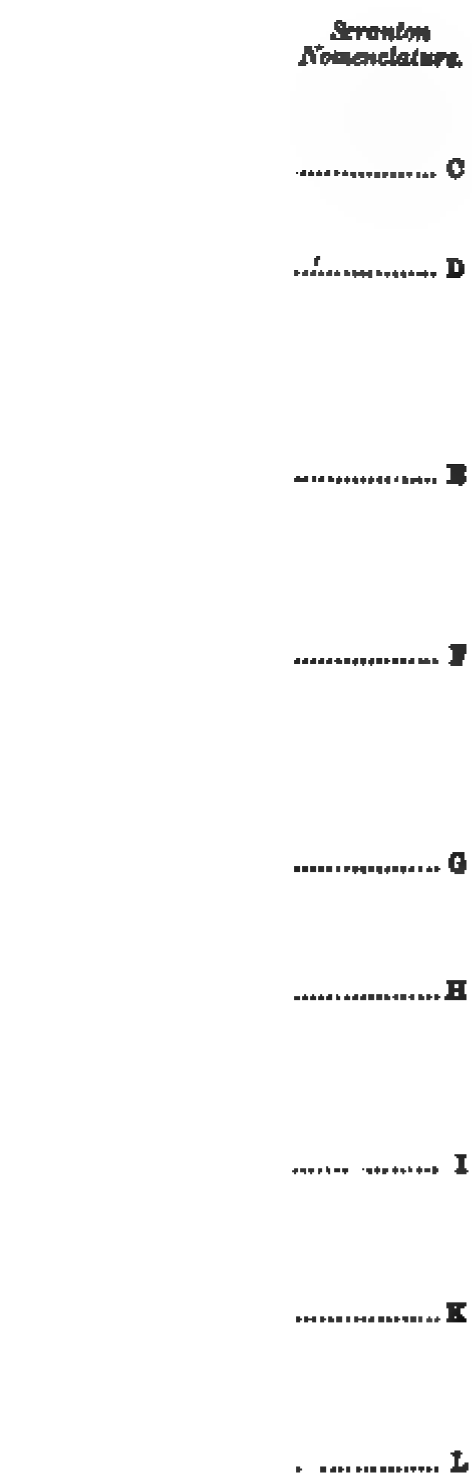
The Lackawanna coal region is the eastern portion or half, or the Northern anthracite coal-field. The Scranton district was the last in this

VIEW OF SCRANTON.

coal-field to be developed, as the Carbondale district was practically the first; but at present it is first both in regard to the state of development

or the amount of production. The Wyoming district was partially developed as early as 1820; the Carbondale district in 1829; the Pittston in 1840, or earlier; and the Scranton in 1855! Yet the enterprise and energy here displayed have thrown all other districts into the shade, notwithstanding the comparatively short space of time in which the work has been done.

Fig. 25.



VERTICAL SECTION AT SCRANTON.

The miners and coal-operators of this district labor under some disadvantages, but the advantages here offered more than counterbalance these objections. The veins are much deteriorated by the numerous bands of slate, bone, and other impurities which are intercalated with the coal. These bands seriously interfere with the work of preparing acceptable or merchantable coal, and greatly increase the labor of mining, cleaning, and separation. But, on the other hand, the coal is obtained at a moderate depth from the surface, and the low angle of dip, approaching the horizontal, enables the miner to put his coal into the drift or mine cars direct, and thus obviates all extra handling. Coal-seams which approach the horizontal,—or from 5° to 10° of dip,—and those which have an angle of from 35° to 50°, can be operated with more economy than those which vary to a greater or less degree when not affected by circumstances of a different nature.*

It will be noticed in the accompanying vertical section that the measures at Scranton are much deeper than at Carbondale, and that the veins are deposited in a greater thickness of intervening strata; but, comparing the section at Scranton with that at Wilkesbarre, we find a still greater difference. The depth at Scranton is less than 500 feet; at Wilkesbarre it is over 1000 feet.

* This subject will be fully discussed under the head of "economical mining," to which we refer for fear of misconception.

There is no difficulty in identifying the veins here with those of other portions of the anthracite coal-fields. Most of the important seams found elsewhere are here developed, though in less dimensions than they assume as a general rule in other regions.

The mining engineers of the Scranton district have adopted a local nomenclature of their own to designate the seams. We have lettered the coal, from the conglomerate upwards, progressively, as the only practicable mode which is applicable generally. The seams which are sometimes found locally in the conglomerate we have not included, since their existence is precarious and their extent and localities are uncertain. We find none of those lower beds in the Northern coal-fields, except a very small one, perhaps, between the upper and lower conglomerate, near Scranton.

At Scranton, the seams are lettered from the top downwards, though there is some uncertainty where to make the commencement. The "big vein," however, is always designated as G, and from this, as a base, those above and below are enumerated.

Fig. 26.

In.
2 coal.
6 Slate.
9 Coal.
3 Slate.
6 Coal.
2 Slate.
Coal.
6 Bony Coal.
Coal.
Bony Coal.
Coal.
9 Slate.
3 Coal.

SECTION OF MAMMOTH, OR G, AT SCRANTON.

The uppermost seam developed as workable coal at Scranton is I, corresponding to the Scranton C; and as they have named the coals from the top downwards, and we from the bottom upwards, the identity is thus:—Our H is Scranton D; G, or Primrose, is Scranton E; F is the same in both columns; E, or the Mammoth, is their G; D, or the Skidmore, is the Scranton H; C is Scranton I vein; B, or Buck Mountain, is their K; J being omitted, though it exists as a small unworkable seam, and is the lowest vein named.

E and G, or the Primrose and the Mammoth, are the two principal beds, and those chiefly worked. These veins vary considerably. The Mammoth, or E, ranges from 12 to 24 feet, and the Primrose, or G, from 10 to 15 feet.

The figures on the left of the accompanying illustration, Fig. 26, denote the thickness in feet and inches of the benches or bands of coal, bone, and slate which constitute the seam, or about 21 feet total thickness. This representation of E, or Scranton G, is from the Bellevue Mines, belonging to the Delaware, Lackawanna & Western Railroad Company. It is in its

maximum dimensions and best condition. We give in the following notes the size and condition of this bed at other points.

COAL SECTIONS AT SCRANTON.

MAMMOTH BED.

E, or G, at No. 1 Shaft.

	Ft.	In.
Top, Blue Slate	2	0
Coal	1	1
Slate	0	6
Bony Coal	1	1
Coal	5	0
Bony	0	6
Slate	1	0
Coal	2	0
Slate	0	6
Coal	0	7
Slate	0	2
Coal	2	4
Hard Slate	0	9
Coal	2	9
Total	18	3
Workable Coal	12	0

E, or G, at No. 2 Shaft.

	Ft.	In.
Coal	1	4
Slate	0	6
Coal	5	0
Slate	0	6
Bone	0	6
Coal	5	0
Total	12	10
Workable Coal	11	4

E, or G, at Rockwell.

	Ft.	In.
Coal	1	0
Coal	4	0
Slate	2	3
Coal	1	6
Slate	0	3
Coal	3	9
Total	12	11
Workable Coal	10	00

PRIMROSE BED.

G, or E, at Diamond Mines.

	Ft.	In.
Slate Top		
Coal	7	0
Bony	1	0
Coal	1	10
Slate	1	2
Coal	0	3
Slate	0	3
Coal	1	0
Slate	0	6
Coal	0	6
Total	13	6
Workable Coal	7	0

FIG. 27.

G, OR E, AT SCRANTON.

SECTIONS OF OTHER SEAMS.

Fig. 28.

Fig. 29.

Fig. 28 is a section of Scranton D vein, or our H, which lies above the Primrose, and corresponds with the Orchard. This section is from the Bellevue mines, and is not worked; at other points it is found in a workable condition, and ranges from five to seven feet in thickness.

Fig. 29 is F, having the same denomination in both nomenclatures, and corresponds with the Holmes, which lies between the Mammoth and the Primrose. This section is from the Diamond Mines, and is near its average proportions and condition in the Scranton district.

Figs. 30 and 31 are I and K at Scranton, and C and B, as we have named them, and as appear on their face. Fig. 31 corresponds to the Buck Mountain vein, which will be found fully exemplified in other regions.

The highest vein at Scranton is C, or I of our scale. The accompanying notes show its size and character.

I, or C, at Diamond.	Ft.	In.
Bony	2	0
Coal	2	0
Bony	1	0
Coal	2	0

Fig. 31.

D, or H, at Bellevue.	Ft.	In.
Coal	4	0
Coal	0	11
Slate	0	8
Coal	1	0
Slate	1	0
Coal	1	8

Seam D, or H, lies under the Mammoth, and corresponds with the Wharton or Skidmore. Its size in the Scranton district varies from seven to nine feet, as a mean, but sometimes it is much less. C and B are worked and used as furnace-coals by the Lackawanna Iron Company.

The total thickness of the workable seams at Scranton is about 62 feet; but of this thickness not less than 20 feet are rejected as refuse or considered unworkable, which reduces the amount of productive coal to 42

feet. The breadth of the basin at Scranton or vicinity varies from three to five miles, and may be estimated, as a mean, at four miles, underlaid by the lower veins. The upper veins do not cover more than half this area: consequently, the workable or productive thickness cannot be estimated as an aggregate over the entire area. We think that 25 feet total thickness over the entire area of the four miles breadth will be fully up to the standard. The length of the Scranton district is not defined, but the above estimate will hold good throughout the Lackawanna region, from Pittston to its eastern extremity.

The mode frequently pursued of finding the total working thickness of coal, and estimating its productibility over the entire area of the field or basin, is seldom practicable. In deep basins, where the veins dip at a high angle, the total thickness will often more than cover the area of the surface; but this is oftener the exception than the rule.

The composition of the sedimentary strata, or the materials constituting the coal measures at their eastern extremity, is finer in grain and appearance than near the centre of the basin at Pittston or portions of the field farther down. It would appear, from these circumstances, that the current depositing the sediment of this portion of the coal-field came from the west; but the inference, from the nature of the sediment, would be that it came from some central portion of the field.

There is no evidence of a rapid current flowing east from Pittston, but there is of one flowing west.

PITTSTON DISTRICT.

This portion of the coal-field lies indefinitely between the Lackawanna and Wyoming regions, and in the vicinity of the junction of the Lackawanna with the Susquehanna, at the entrance of the latter into the valley.

The coal measures are more disturbed and irregular in this locality than in any other portion of the field. The veins, of course, partake of the same influences, and are found dipping to every point of the compass; they are, therefore, not as reliable nor as economically mined as in the more uniform portions of the field. Generally, the formations of the northern anthracite fields are remarkably uniform,—much more so, in fact, than either of the other anthracite fields.

When we state that the Pittston district is less reliable as a mining district than some other portions of the field, we do not, by any means, condemn it. In comparison with our coal-fields generally, its condition is favorable. Though the coal is not generally as uniform as that of the Scranton district, it contains less slate and impurity; and while not as productive as the Wilkesbarre district, the coal will be more accessible from the surface, eventually, than that of the deeper basins to the west.

There are some peculiarities in this district and vicinity which claim our attention. First, the intermediate basins are irregular, and the uniform east-and-west axis, which prevails generally throughout the field, is interrupted by frequent swells. These basins are less elongated or trough-like, and more elliptical and round,—more frequent, and, of course, more contracted in area. There is no uniform dip and strike, but the undulations of veins are in all directions. To this rule, however, there are notable exceptions, as we before stated; and one of these seems to be on the north side of the Lackawanna, where the measures show a long stretch of gently inclining south dip.

The second peculiarity which we note is the exceeding coarseness of grain prominent in the coal measures in the Pittston district. There are localities in both the first and middle coal-fields where the same coarseness exists; but in the Northern coal-field we have nowhere else noticed this prominent feature of the Pittston district.

A third peculiarity exists in the frequent *erosions* or denudation of the coal-seams to a great depth in this locality. At a depth of from 100 to 160 feet from the surface, the measures have been removed, in certain localities, and their place filled with sand and boulder-stone.

Fig. 32.

DENUDATION, OR EROSION, AT PITTSTON.

The accompanying illustration, figure 32, will convey an idea of this form of denudation. Its locality is nearly opposite the entrance of the Susquehanna through the mountain into the valley. It does not seem to be the regular bed of a channel, but rather the effect of rushing and rebounding waters since the formation of the coal-beds; and the portions swept away may be taken as an evidence of the violence with which the river first made its entrance into the valley. The same evidence of violence exists in the denudations of the strata at many points in the vicinity of the present bed of the river, from Pittston to Kingston, which may be noticed in our transverse section illustrating the basin at or near Wilkesbarre. These erosions can only be explained as thé effects of the violence of the waters of the Susquehanna at an early period, yet long after the formation of coal. It does not appear that the river broke through the huge Shawanee at one violent effort, but rather on the slow, eating principle of the cataract, which would have just the effect which we find

resulting, since the precipitated waters would cut away the comparatively soft rocks of the coal measures to a considerable depth and great distance.

There is some probability that the waters of the basin or ancient lake in which this coal was formed came into the valley at the point now occupied by the Susquehanna. Only on such an hypothesis can we account for the peculiar coarseness of the deposits and the irregularity of the basins here, while the sediment diminishes in amount and in coarseness of texture east, and increases in amount, though not in coarseness, west.

We have not been able to obtain a reliable vertical section in the Pittston district. The only parties in possession of the information accessible were the Pennsylvania Coal Company, and they refuse to impart it. From the facts ascertained, however, we do not consider the total thickness of workable coal to be as great as it is in the Scranton district.

We can furnish nothing reliable concerning the measures, or the coal below the Pittston or 14-foot vein, which corresponds to E, or the Mammoth.

Section at No. 6 Shaft, Pennsylvania Coal Company.

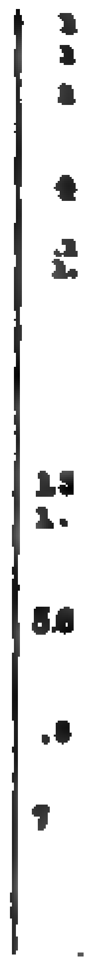
	Feet.	Inches.
Surface	18	0
Rock	20	0
Slate	5	0
Conglomerate and sandstone	15	0
Coal	0	6
Slate	42	0
Fire-clay	2	0
Rock, coarse	20	0
Slate	3	0
Coal	3	6
Fire-clay	1	0
Rock	52	0
Coal, checkered and bony (not worked)	6	0
Rocks and coarse sandstones	113	0
Slate and bone	5	0
Coal (bed E)	14	0

Continued from a Section taken above Pittston on other land.

Gray rock, coarse	35	0
Coal, 7 to 9 feet, D	8	0
Slates and sandstones	50	0
Coal, 3 to 5, C	5	0
Slates and sandstones	50	0
Coal, B	3	0

We illustrate the Pittston 14-feet, or Mammoth, with two sections,—one in its maximum and the other in its minimum condition. We note in figures several other sections in the same vicinity.

FIGS. 83 and 84. *E Bed, or Pittston, 14 feet, at the Rough and Ready Colliery.*



SECTIONS OF E, AT TWIN SHAFT AND TOMPKINS SHAFT, PITTSTON.

	Feet.	Inches.
Coal, coarse rider	1	0
Slate	1	6
Coal	4	6
Bone	0	3
Slate	0	6
Coal	3	0

Workable coal, 7 ft. 6 in.

E or Pittston bed, at the Butler Colliery in Pittston.

	Feet.	Inches.
Top, slate and sandstone		
Coal, rider, coarse	1	6
Slate	0	3
Coal	7	0
Bone	0	2
Coal, extra	2	0
Bone and slate	0	8
Checkered coal	1	6
Coal	3	0

Workable coal, 13 ft. 6 in.

NOTE.—The upper section is from the Twinn shaft, above Pittston, and the lower section from the Tompkins shaft, below Pittston.

The depth of the measures in the vicinity of Pittston is not over five hundred feet generally, and rather less, as a rule, than in the Scranton district; though there may be localities where the measures will exceed 700 feet in thickness.

The Pittston coals are not as hard as the coals in the lower end of the basin, nor as tenacious as the coals of the Scranton district; but they are considered by some a better steam coal than the former, while they contain less ash than the latter.

THE WYOMING REGION PROPER.

We include under this head all the lower or western end of the Northern coal-field, from an indefinite point near Pittston, to Shickshenny. It comprises the most valuable portion of the field, containing the best coal and the largest amount of it. The seams at present, along both edges of

the field, are easily accessible, and will be productive, at moderate depths, for a long period; but eventually deep shafting will have to be resorted to in the central portions of the valley.

The accompanying transverse section illustrates generally the form of the basins, axes, or undulations, which have a uniform course nearly east and west; while the dips are equally uniform north and south.

WILKESBARRE DISTRICT.

The accompanying illustration, Fig. 35, of the Wilkesbarre basins gives a good general impression of their form and features; but it is by no means exact in proportion or measurement. It is an ideal section, formed from such data as were accessible. We may point out a few errors which those practically familiar with the district will detect. The number of basins between Wilkesbarre and the mountain is uncertain, but they run deeper, in all probability, than the section indicates. Our artist, though very skilful, has transposed the seams, as may be noticed, in crossing the basin, and has placed more veins on the south than the north side. Otherwise, the illustration conveys as correct an impression of the coal-basins in the Wilkesbarre district as can be furnished by the present state of their development.

Fig. 35.

TRANSVERSE SECTION AT WILKESBARRE.

For the information of those not familiar with the region, we may state that this view is from the west towards the east. Wilkesbarre is represented by a number of houses on the right or south side, and Kingston by a large house on the left or north side. The white dotted space between the two is intended to illustrate the erosion or denudation which has taken place generally in the vicinity of the river, to a considerable depth, from this point to Pittston.

The probable depth of the central portion of the basin is from 1000 to 1500 feet; and in localities between Wilkesbarre and Nanticoke the depth is undoubtedly greater. The first seam of any note cut in the Dundee shaft, which is nearly opposite Plymouth, is about

700 feet from the surface. This vein is one of the upper ones, as shown in the accompanying vertical section, and must be nearly a thousand feet from the bottom of the basin at that point. The depth perhaps of the larger portion of the coal on each side of the central basins is within 750 feet of the surface.

Fig. 36.

VERTICAL SECTION AT WILKESBARRE.

In figure 36 we give the total thickness of the measures at about 1000 feet, including 10 veins of workable coal, with an aggregate thickness of from 80 to 100 feet. There is some doubt as to the thickness of the lower veins, particularly B and C, whose thickness we have not given. They are generally estimated to be over 20 feet respectively; but we think they will eventually be found less. We are aware that the Mammoth, or E, folds over abruptly in some localities, and may be mistaken for an underlying vein; but it will not be found at any considerable depth. This feature of the Mammoth or Baltimore vein is fully developed at the Hollenback mines, now operated by the Consolidated Company, where the slope on the seam abruptly terminates and the bed itself turns back at nearly the same angle. It would confuse and interrupt our description to explain this feature of inverted dips here, but in another place these irregularities of formation will be fully discussed and illustrated.

Prof. Rogers places the Baltimore bed E as the upper seam of his lower series, and the Pittston fourteen-foot vein E as the lower bed of his upper series. This is evidently an error, as it is now positive that those two locally distinct names apply to the same vein, and that the Baltimore vein at Wilkesbarre is synonymous with the fourteen-feet vein at Pittston, while these are in turn identical with the Scranton G vein and the Mammoth or E of our nomenclature.

There is more uncertainty about the veins above the Baltimore bed, and some obscurity attending the seams below; but generally they can be recognized as identical with the seams at Scranton, or those of Mahanoy or Pottsville. We think it probable, however, that the "Primrose" at Wilkesbarre and Nanticoke is H rather than G, and that both F and G are between the Mammoth and Primrose at Wilkesbarre. It is known that two seams exist in most regions within this space,

but one of them is generally so small as not to merit a position among workable veins. We should have placed all the seams, both small and large, in our vertical columns, instead of the workable seams only, if it had been possible to obtain the necessary data. In the Pottsville column will be found most of the small intervening seams, which will be noticed particularly from the fact of their not being lettered or named.

The veins in the Northern coal-field all produce a white-ash coal,—or those which have been worked to the present time. We do not know of a single instance in which the upper or red-ash seams have been operated for the market. We think it probable the upper seams in the Wyoming region are of the red-ash variety; but, though they may be identical with the red-ash veins of the Pottsville district, it does not necessarily follow that they must be red-ash also, since the causes producing the coloring of the ash—the oxide of iron, &c.—are local.

One of the lower beds in the Wyoming region, which we have denominated B, but which Rogers and others identify with the Baltimore bed E, produces a red-ash coal from one of its lower benches, which is a distinguishing feature of B, wherever found. The large and magnificent Grand Tunnel bed, and the Lee vein at Nanticoke, are identical with B,

Fig. 87.

Fig. 88.

Fig. 89.

B, OR GRAND TUNNEL VEIN, AT LANCE'S GRAND TUNNEL MINES.

B, OR BUCK MOUNTAIN, AT CAREY & HART'S, SNICK-SHENNY.

B, OR BUCK MOUNTAIN, AT EXTREMITY OF COAL-FIELD SNICKSHENNY, OR ROCKY MOUNT.

or the celebrated Buck Mountain. We know there is a diversity of opinion about this matter; but we think the facts are positive.

The Baltimore bed E depreciates in size as it runs west, but preserves its excellence and purity; while the Grand Tunnel vein B depreciates rapidly in both size and character as it spreads east. It is rather a difficult matter to determine whether the Patten or Bennett vein at Plymouth is the Baltimore or the Grand Tunnel. We have never personally examined the Plymouth district, and cannot speak from experience in regard to this question.

We give on page 181 three sections of the Buck Mountain, Grand Tunnel, or B vein, as operated at the several localities in the western end of the field. It will be found to correspond not only in each locality in the Wyoming region, but also in the Lehigh basins.

This is the lowest workable vein in the anthracite coal-fields. At Nanticoke its position is clearly defined, as resting on, or nearly on, the conglomerate, but underlaid by the invariable bed A, which is always small and always on or in the conglomerate. At West Nanticoke the same conditions exist. The Harvey and the Grand Tunnel mines are in this seam; and here, as at Nanticoke, it rests on or near the conglomerate, with only one small seam of three or four feet below it. The Baltimore vein, clearly, cannot be the same, since there are at least four seams beneath it, as shown in every section we have made; and our data are in all cases official, and from the best practical local sources.

The lower benches of B produce a red-ash coal, not only at Nanticoke, but at the Lehigh Buck Mountain mines, and wherever the bed B is operated. It is distinguished almost invariably by a heavy parting slate which divides the vein near its middle. This will be noticed in every section we have given of this seam, except at the New Boston mines, on the Broad Mountain, in Schuylkill county; but even there the character and appearance of the coal are the same.

We think, therefore, that the Grand Tunnel, or Lee's Nanticoke vein, is not identical with the Baltimore bed, and that it probably underlies the Bennett or Patten vein at Plymouth, but in all probability much depreciated. In no part of the valley do the conditions necessary to the production of coal exist more favorably than in the vicinity of Nanticoke, or between that and Plymouth. The lower veins, therefore, attained a larger size here than at any other part of the valley, or, perhaps, in the anthracite regions; but whether the succeeding seams were formed in the same proportion does not appear: they have been denuded or carried away by the rush of waters through the Nanticoke defile, which occurred long after the formation of these coal-seams.

We may here remark a general law of those early formations. In all cases where the basins are comparatively shallow, but not excessively so, and the base-rocks are even and uniformly laid at low angles, the lower beds are large and productive, but the upper ones seldom appear, simply

because the shallow depths of the measures do not admit of their formation. The Grand Tunnel bed is laid on a gently inclining surface, which must have existed at no great depth in the basin; when followed below water-level, the dimensions and general character of this vein depreciate rapidly, as demonstrated at Lee's Nanticoke mines; and the probability is that this vein will be quite lean and small in the deep basins of this vicinity, as it is further east.

The Baltimore bed was at first worked as an open mine, or quarry, in the vicinity of Wilkesbarre, where it is very thick and productive. The character and purity of its coal cannot be excelled, and are only equalled by some of the Ashland and Lehigh coals from E, or the same vein.

Operations on the Baltimore bed commenced at an early date, and most of the coal sent from the Wilkesbarre district has been obtained from this vein alone: yet but a small amount of its area has been extracted. Few veins have been more productive than this. It is from 18 to 24 feet thick, and, consequently, yields a large amount of coal per acre. The roof, or top-rock, is solid and substantial; the amount of overlying surface is not great in the area operated on; while the low angles of dip admit of the coal being worked without much waste, and with great economy. As long as this vein remains productive at moderate depths from the surface, the seams below and above it will remain in comparative idleness, or in an undeveloped condition, though some of them are good, reliable, and productive seams.

FIG. 40.

FIG. 41.

E, OR BALTIMORE VEIN, AT DIAMOND MINES, WILKESBARRE.

PATTEN VEIN E, AT PLYMOUTH.

The Baltimore or E vein, at Wright's mines, in Newport, or the lower end of the Wyoming Valley, is rather less in size than at Wilkesbarre;

but the coal is excellent. We give the following notes in relation to its thickness.

E, at Wright's Mines, Newport.

	Feet.	Inches.
Top—hard slate and sandstones		
Coal, rider, good	1	6
Bone and slate	0	6
Coal, solid and pure	10	0

Before closing our remarks in reference to the beds B and E, we are bound to say there is something inexplicable to our present comprehension in the Plymouth district. It would almost appear that the Baltimore and some underlying vein united there, or below that point, to form the Grand Tunnel bed. We find at the Chauncey mines of the Union Coal Company the Grand Tunnel vein divided by 5 feet of slate, with 9 feet of top coal and 10 feet of bottom coal; while at no great distance we find, at the Sweatland mines of Langdon & Co., a ten-foot upper coal, known as the Cooper, and a 14-foot lower coal, known as the Bennett vein, divided by 30 feet of measures. But, as we before observed, this district is a terra incognita to the writer, and all attempts to gain information from those who ought to know have remained unanswered.

SECTION OF FORMATION AT NANTICOKE, AS GIVEN BY COL WASHINGTON LEE, SR.

	Feet.	Inches.
Surface, coal	4	0
Coal, slates, sandstones, and small seam 12 inches	100	0
Coal	4	0
Slates and sandstones (40 to 60)	40	0
Coal	5	0
Slates and sandstones	60	0
Coal—Nanticoke or Primrose—G	7	0
Slates and sandstones	100	0
Coal—small, bony seam, red-ash—(3 to 4)	3	0
Slates and sandstones (35 to 50)	40	0
Coal—forge, or Holmes vein—F	5	0
Slates and sandstones	150	0
Baltimore coal—undeveloped	?	0
Slates and sandstones	150	0
Coal—D	5	0
Slates and sandstones	40	0
Coal—C	4	0
Slates, rock, and conglomerate	90	0
Coal—Lee's vein, Buck Mountain, or B	14	0
Conglomerate—slate	30	0
Coal—A	5	0

The lower end of the Wyoming Valley, below Nanticoke, is known as the Newport Valley, which is some four or five miles in extent. Across this section of the valley runs the transverse line of the cross-section which accompanies our map of the anthracite fields, delineating the formations from the old Lehigh mines at Summit Hill to the point here designated.

Though the valley does not extend more than five miles west of Nanticoke, the basin pursues its course beyond Shickshenny,—a distance of nearly twelve miles from the Nanticoke defile. At the extremity of the valley a dividing ridge sheds the water to the west, into the Susquehanna, below Shickshenny. The coal-basin below Nanticoke is but little developed, but such explorations as have been made exhibit this portion of the field in a favorable light. The coal is good and well adapted for furnace purposes, and the veins are of respectable dimensions. A new coal district has recently been created at Shickshenny by the operations of Messrs. Carey & Hart, who are opening the lower end of the basin on a large scale. They are working on the lower veins. Fig. 38 is a section of the lowest workable one.

Accompanying will be found the names of the firms or companies operating in the Northern coal-field, and the amounts shipped by them during 1864.

PRODUCTION OF COAL IN THE NORTHERN COAL-FIELD.

The Carbondale District.

Allen Anderson	1,530	Brought forward,	881,756
Stephen S. Clark	1,880	S. P. Williams & Son	493
Delaware & Hudson Canal Co.	875,671	Eaton & Co.	742
Elk Hill Coal Co.	219	John Jermyn	252
James Nichol	2,106	E. Jones & Co.	115
Kittery & Beard	90	Wm. & D. R. Moore	1,083
John Oakly	260	Williams & Nichols	146
	881,756		884,587

Scranton District.

D. L. & W. R. R. Co	1,215,351	Brought forward,	1,324,780
Hunt, Davis & Co.	1,628	Peter Mills	60
Lack'a Iron & Coal Co.	90,196	Leander Vanstorch	150
Sus. & Wy'g Val. Coal Co.	14,819	Charles W. Edward	610
Thomas Griffin	56	Daniel Howell	1,332
Jermyn & Griffin	2,230	S. Scranton & Co.	19,719
John Hancock	110	A. S. Washburn	5,002
Kinsted & Leach	390	Mt. Pleasant Coal Co.	859
	1,324,780	Phinney & Schott	309
			1,352,821

Pittston District.

Pennsylvania Coal Co.	828,463	Brought forward,	1,141,751
Butler Coal Co.	30,508	Thomson & Childs	3,062
James Freeland	14,718	Hancock & Foley	4,683
Murcur & Co.	85,569	Joel Bowkley	50
Murcur & Frisbie	79,376	John Mitchell	14,346
Maryland Coal Co.	25,084	J. H. Schwager	2,675
Abram Price	23,949	Wyoming Coal & Tra'n Co.	24,205
G. B. Welsh, agent	16,051	John R. Stark	200
Thomas Waddle	12,283	Samuel C. Wilcox	100
B. C. Hurd & Co.	5,896	Corbright & Hines	343
T. & W. Leyshon	19,854	Rodman Merrit	955
	1,141,751		1,172,370

Wilkesbarre District.

Baltimore Coal Co.	133,953	Brought forward,	444,727
H. B. Hillman	19,384	Lehigh & Susq'a Coal Co.	20,896
Consolidated Co.	244,680	Lewis Landmesser	6,622
David Mordecai	1,563	Wyoming Coal & Iron Co.	1,109
Curtis, Standish & Co.	61	S. D. & H. M. Hoyt	277
Audenreid Coal & Impr't Co.	15,703	James P. Atherton	588
Franklin Coal Co.	29,383		474,219
	444,727		

Plymouth and Nanticoke Districts.

Ira Davenport	1,572	Brought forward,	91,728
Charles Hutchinson	5,104	J. Langdon & Co.	44,195
Union Coal Co.	11,139	David Morgan	53,113
Bennet & Davis	3,687	John S. Shonk	482
S. C. Fuller	23,827	Shonk & Lance	3,073
John B. Smith	27,423	James Nicholas	200
William L. Lance	2,679	Harvey Brothers	14,753
Grand Tunnel Coal Co.	16,297		207,544
	91,728		

Shickshenny District.

A. H. Church	6,786	Brought forward,	8,494
John Thomas	220	L. H. Waterberry	18
N. T. Beadle	2,488		8,512
	8,494	Carbondale	884,587
		Scranton	1,352,821
		Pittston	1,172,370
		Plymouth	207,544
		Total,	3,625,834

NOTE.—These returns are from the Commissions-Books. The names of the miners and shippers will be found corrected in the Appendix.

CHAPTER IX.

THE LEHIGH COAL-BASINS.

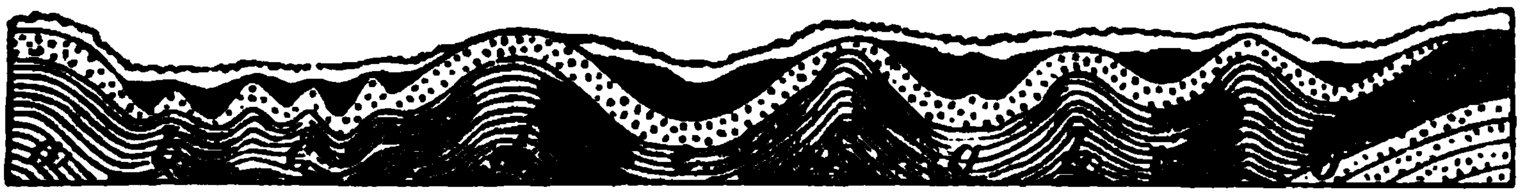
The Lehigh Basins not the old Lehigh Mines—Lehigh Coal-Basins—Sections at Tresckow, Coleraine, and Jeansville—Honeybrook—Hazleton Coal-Basin—Barren Measures—Buck Mountain Bed—Big Black Creek—Harleigh—Ebervale—Jeddo—Eckly—Little Black Creek —Lower Black Creek—Extent of the Lehigh Basins—Production of the Lehigh Basins.

We do not propose to include under this head the old Lehigh Summit mines or the Room Run mines: they belong properly to the first or Southern anthracite coal-field, in the eastern end of which they are located.

Under the general head of the Lehigh coal-basins we include those comparatively small fields or basins of coal lying between the first and third anthracite coal-fields, and to the east of the second or Middle coal-field, in which they are sometimes, though not properly, included. They have a separate and distinct existence, and are as peculiar in their form and features as any of our independent coal-fields; but they resemble each other, in general structure, character, and quality of coal, very closely. They are all comparatively narrow, and generally shallow, containing only the lower or white-ash veins; but these are in their most favorable conditions. They are large, uniform, and productive, and include the Mammoth and all the underlying veins.

Below we give a transverse section of the four principal parallel basins, with their undulations and intermediate basins or synclinal troughs.

Fig. 42.



LEHIGH COAL BASINS.

Figure 42 is a cross-section of the Lehigh coal-basins from the Spring Mountain, *a*, on the south, to Green Mountain, beyond the Green Mountain basin, *j*, on the north. The distance across those basins is between six and seven miles, while their maximum length is about twelve miles.

The Beaver Meadow Basin lies between Spring Mountain, *a*, and Pismire Ridge, *d*. The section represents a point near the middle of the basin in the vicinity of Jeansville; *b* is the location of Tresckow, on the German Pennsylvania Coal Company's property, and *c* the position of Jeansville.

The Hazleton Basin, *e*, is the largest and deepest of the group, and lies between Pismire Ridge, *d*, and Council Ridge, *f*.

Big Black Creek Basin, *g*, is the next in order, and is located between Council Ridge and Black Creek Ridge, *h*. Following these, to the north, are the Little Black Creek Basin, *i*, and the Green Mountain Basin, *j*.

The Green Mountain basin is comparatively small and not yet developed. The principal basins in the section, and in this, the Lehigh region, except the Lower Big Black Creek basin, are the Beaver Meadow, Hazleton, Big Black Creek, and Little Black Creek basins. The Lower Black Creek basin is a continuation of the Big and Little Black Creek basins, though their continuity is probably broken at the point of intersection by an elevation of the conglomerate which "throws the coal over," in mining phraseology. A glance at the accompanying map will be necessary to obtain a comprehensive and clear impression of this group.

There are three or four other small patches of coal within this cluster of Lehigh basins: one of these, the Dreck Creek basin, lying between the Beaver Meadow and Hazleton basins, we have not laid down on the map, on account of the uncertainty of its character and the insignificance of its size. We must here remark, however, that this narrow and shallow trough of coal has never been fairly tested, and we have neither data nor authority which would justify a condemnation of this basin.

Another of those small narrow basins exists on the Big Tomhickon Creek, which appears to be a continuation of the south fork of the Hazleton basin, extending from its western extremity. This basin is of more importance than the Dreck Creek basin, but we believe it does not contain the Mammoth vein. There are several other small patches of coal in this vicinity, of which, however, nothing very definite is known. The McAuley Mountain deposit can scarcely be called a basin, as it is on the top of a mountain, yet has the basin-shape, and has only been preserved from the powerful denuding forces which broke up this portion of the region by the heavy conglomerates and sandstones which underlie the deposit, and which resisted the rush of waters. The McAuley basin is detached from the main group, and exists as the most western of the series, and appears as a prolongation of a coal formation formerly existing in the Nescopeck Valley. The evidence of the former existence of coal to the west and northwest of the present Lehigh group is the numerous beds of conglomerate which cap the elevations throughout this region. The undulating character of the Umbral or red shale strata, and their fine, soft, yielding nature tells the story of destruction which the rocks around so fully confirm.

The Lehigh group occupy part of a vast undulating plateau that formerly existed from the Nesquehoning to the Nescopeck Mountains, and which filled the deep wide valleys now occupied by the Quakeake and the Nescopeck streams. The blue color on the map distinguishes the existing portions of the conglomerate, as the black denotes the coal. The pink represents the red shale or Umbral; and those wide areas shaded by this color were undoubtedly once covered by the blue, or base-rock of the coal ısures, if not the coal itself. The elevation of this conglomerate plateau

is about 2000 feet above the sea-level, while some of its deepest coal-basins are nearly 1000 feet below the surface, or only 1000 feet above the sea. Yet the lowest part of the deepest basins is far above the surface-level of the Pottsville basins, which are probably over 3000 feet deep, or 2500 feet below the level of the Atlantic. Port Carbon is 600 feet above tide-water, and Hazleton about 2000 feet. The depth of the basin beneath Hazleton is 900 feet, which still leaves a difference of 500 feet between the bottom of the deepest Lehigh basin and the top of the deepest Schuylkill basin.

The Schuylkill basins were originally deeper than the Lehigh basins; but there can be but little doubt of the fact that the surface, or rather outcrop, of the coal at Pottsville was at one time on a level with the surface or outcrop of the coal at Hazleton. The depression has been since the formation of coal, or, perhaps, continued during its formation. The Lehigh basins have not been elevated, as some suppose; but, on the contrary, the Schuylkill basins have been depressed, as their steep angles and reversed or overtilted strata amply testify.

The area of the present conglomerate plateau, on which are located this group of basins, is between 150 and 200 square miles, while the coal area is between 35 and 50 square miles. The probable ancient or denuded area is not less than 1000 square miles.

THE BEAVER MEADOW BASIN.

This is the first or most southern of the Lehigh basins, and extends from a point several miles east of the village of Beaver Meadow to its western terminus near Mount Alter, some two miles from the Honeybrook mines, the distance being about 12 miles, and the average breadth less than a mile, with a total area of nearly 10 miles. The formation extends across the Beaver Meadow and Hazleton Railroads, a short distance north of Weatherly, but is entirely devoid of coal; and the probability is that little coal exists east of Beaver Meadow.

The mines in the vicinity of Beaver Meadow were for a considerable period very productive, but being operated in a primitive manner, and much troubled with water, they have been abandoned, though far from being exhausted. To reopen them will be costly, and no one cares to risk the expense when virgin fields invite them.

Above Beaver Meadow, or between it and Jeansville, are the Coleraine mines, now worked by Messrs. William Carter & Son. At this point the basin is over 1000 yards wide, and contains three subordinate basins or troughs, besides one or two small undulations. The depth of the basins is from 500 to 700 feet.

The following vertical section is a representation of the measures both

at Jeansville and at Coleraine, as there is but little difference. At neither place has the Buck Mountain, or B vein, been developed.

FIG. 43.

The section at Jeansville is nearly similar, as given below.

	Feet.	Inches.
Surface	186	0
Mammoth	30	0
Slates and sandstones	100	0
Wharton—D (8 to 12)	8	0
Slates and sandstones	100	0
Coal—C	4	0
Slates and sandstones	100	0
Unexplored	50	0
Conglomerate		

The foregoing figures are from the north basins at Jeansville. The south basin at Tresckow differs slightly, as shown by the following notes from the data furnished by M. Dagenhardt, of the German Pennsylvania Coal Company, whose information is derived from correct measurements; and, as it differs so widely from the published accounts of the State geologists, and some of our eminent engineers, who denied the existence of the Mammoth at this point, the notes may be interesting.

VERTICAL SECTION OF THE BEAVER MEADOW BASIN.

SECTIONS AT TRESCKOW.

Mammoth Vein, E.	Feet.	Inches.
Top slate		
Coal	6	0
Bone	0	3
Coal	4	0
Bone	0	1
Coal*—"poor man's"	2	0
Bony coal	0	4
Coal	7	0
Bony coal and slate	1	0
Coal (from 4 to 7)	5	0
Coal	25	0
Slate		8
Total	25	8

* This singularly named bench of coal is of good quality.

Vertical Section.

	Feet.	Inches.
Surface	150	0
Mammoth E	30	0
Slates and sandstones	90	0
Wharton, D	8	0
Slates and sandstones	90	0
Coal, C	8	0
Slate and rock, 10 to	30	0
Red shale	?	

(Buck Mountain?) Vein C.

	Ft.	In.
Coal	4	0
Slate	1	6
Coal	4	0

Wharton Vein, D.

	Ft.	In.
Slate-top		
Coal	4	0
Fine, dark slate	1	6
Coal	4	0

FIG. 44.

Section of Mammoth at Jeansville.

	Ft.	In.
Top—hard rock		
Slate	2	0
Coal	1	0
Bone	0	2
Coal	1	0
Coal	6	0
Sulphur	0	4
Coal	8	0
Mining, or charcoal	0	4
Coal, "poor man's," pure and good	2	0
Hard slate	0	4
Checkered coal	1	6
Slate	0	2
Coal, very fine	7	0
Hard slate	0	2
Coarse coal	1	0
Bone	0	4
Coal	4	0
Coal	24	6
Slate, &c	3	10
Total	28	4

MAMMOTH AT COLERAINE.

SECTIONS AT COLERAINE.

Wharton Vein, D.

	Ft.	In.		Ft.	In.
Coal	4	0	Slate	0	8
Slate	0	1	Coal	4	0
Coal	0	6			

Vein C (Buck Mountain?).

	Ft.	In.		Ft.	In.
Coal	4	0	Coal	3	0
Slate	1	0			

NOTE.—The Buck Mountain bed is B in all our sections, except where C take its place; and this is always in error. We think it probable the bed here named C is really B, and the C, and not B, is the missing seam.

There are five undulations, or synclinal axes, at Jeansville, across the basin. Farther west these synclinals separate, and form two terminal points to the basin. The three southern troughs continue on west, and form the deep and superior basins at Honeybrook, and the two northern troughs or synclinals form the less developed basins on the old Frenchtown property.

At Honeybrook the southern portion of this basin is 3570 feet wide, and is divided by three synclinals or subordinate basins, as before stated. The two southern basins are the widest and deepest. We are scarcely prepared for the data here developed, or the difference that exists between this locality and those farther east.

The total depth of the measures is given by Mr. George Allen, the practical and experienced superintendent, at 580 feet. We think this, however, rather over than under the correct thickness, from the fact that in no other portion of the coal region do we find the distance to be so great from the Mammoth to the conglomerate or lower veins, as here given.

At Hazleton the distance from the Mammoth to the Buck Mountain is from 300 to 400 feet. At Harleigh, in the Black Creek basin, the depth is from 400 to 500; but here, at Honeybrook, it is given as over 580 feet. There is room to doubt this, not only from the fact of its being unusual, but because no developments have been made to prove it.

It is singular that only two veins are given in those deep measures below the Mammoth, while in all other portions of the anthracite coal-fields there are *three* and *four*. In fact, four veins exist below the Mammoth in every other basin of note except that of Carbondale, and there is no good reason to doubt its existence here, since the ground has not been thoroughly explored, and there is plenty of room for the Buck Mountain vein. The miners of the Beaver Meadow field or basin denominate vein C as the Buck

Mountain, which is everywhere else B. Of this fact there can be no doubt. The B, or Buck Mountain, is always the lowest workable vein, lying on the conglomerate, and overlying A, which is *in* the conglomerate. We think the fairest and best exposition of the lower coal measures has been made in the New Boston basin, which is similar to the Lehigh basins, by J. Louden Beadle, Esq., who has carefully proved each vein and measured their respective distances. A reference to that basin shows a strict conformity with both the Hazleton and Black Creek formations, as they all in turn conform to the measures of the coal-fields generally. There is some doubt on this subject among our mining engineers, but we have fortified ourselves with facts from so many practical sources that the proof is overwhelming; that is, of the general existence of four veins below the Mammoth.

We therefore state it as our belief that the same number exist in the Honeybrook basins, where the measures are found in their fullest development; but we do not think the measures below the Mammoth are over 500 feet thick.

Fig. 45.

The size of the Mammoth at Honeybrook is 35 feet; the Wharton 10 feet, and C (Buck Mountain?) 8 feet. We propose to give in another portion of this work a full and complete description of the Honeybrook basins, as one of the most interesting localities in the Lehigh region.

We have not intentionally omitted the locality of Yorktown, between Jeansville and Audenreid or Honeybrook. The chief features of those localities are so much alike that it would be only a repetition to describe each colliery in this connection. We propose to mention the colliery establishments in another portion of the work and under a different connection.

THE HAZLETON BASIN.

The town of Hazleton is near the middle of the Hazleton basin, and is 15 miles from Penn Haven, on the Lehigh River, with which it is connected by rail. This is the largest of the Lehigh basins, and is about 13 miles long by one mile wide as a maximum. It contains about 10 square miles of coal formation. The eastern extremity is at the old Buck Mountain mines, some six miles from Rockport, on the Lehigh, and the western point near the Schuylkill county line. This basin lies in Luzerne county, while the Beaver Meadow lies in Carbon and Schuylkill.

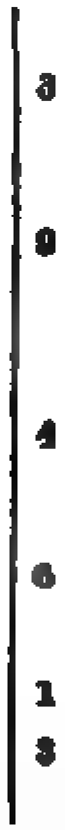
VERTICAL SECTION AT HAZLETON.

The accompanying section though the basin at Hazleton does not repre-

sent the measures above the Mammoth, which appears to be barren, with the exception of one small seam some 4 feet in thickness.

It is singular that the 900 feet of coal measures overlying the Mammoth here should contain no workable coal, while in every other locality in the anthracite regions the same thickness would bear at least four or five workable veins, and in some instances double the number of seams, small and large. The strata and appearances of the measures are certainly of the coal-bearing order, and every indication would suggest the existence of coal above the Mammoth. There are only two solutions: it either does exist and has not been developed, or the measures overlying the Mammoth are not in reality as thick as they would appear, but are *doubled* by a singular process at this peculiarly deep portion of the Hazleton basin, since it is not generally as deep in other parts as in the vicinity of the Diamond mines, where the foregoing section was taken.

Fig. 46.



SECTION OF BUCK MOUNTAIN, BED B, AT THE BUCK MOUNTAIN MINES.

To describe this peculiarity would complicate the description. It will be found exemplified under the head of "Faults and Irregularities of the Coal Formations." (See figure in that connection.)

The Buck Mountain mines are located on the extreme eastern point of the Hazleton basin, though a narrow anticlinal divides the Buck Mountain synclinal from the eastern undulations of the main basin; but it is comparatively small, as shown in our map of the anthracite fields. This eastern portion of the basin is narrow and shallow, and contains only one workable vein, which is the celebrated "Buck Mountain," or B.

It lies on the conglomerate in the same manner as at Lee's Nanticoke mines, and is underlaid by the small seam A, in the conglomerate and overlaid by C, which is here a small, 18-inch seam.

The Buck Mountain vein is here over twenty feet in thickness, and contains about 16 feet of excellent coal, which has become celebrated as a steam coal under that name. The accompanying illustration, figure 46, gives a fair representation of the bed.

This vein has all the characteristics of the lower workable coal-bed, wherever found, in the anthracite fields. In the deep basins of Schuylkill, however, it is small and poor.

It is divided by the accompanying middle slate, as at Shickshenny, Nanticoke, and Grand Tunnel, and wherever found, within our experience, except at New Boston. The lower bench of six feet produces a *dark-red ash*,—so deep, in fact, that it makes the whole vein a "red-ash coal" when

mixed, though the top bench of nine feet is white ash. This peculiarity of the Buck Mountain vein is also a characteristic of the Grand Tunnel and Lee's Nanticoke beds, which occupy a relative position at the base of the coal measures. Another identifying peculiarity of the lower coal of this bed, wherever found in good condition, is its density, tenacity, and conchoidal fracture,—resembling the white-ash coals in this respect, but differing from the upper red-ash coals generally.

The basin at the eastern extremity is shallow and narrow. No. 2 slope, in operation, is about 270 feet long on an angle of 40°. The bottom of the slope or basin is 150 feet vertical from the surface. This is in the old Buck Mountain basin, which is elevated and on the eastern point or side of the Buck Mountain, or a continuation of Council Ridge. The Black Creek basin lies about half a mile to the south, over a dividing ridge which is overcome by planes. Here the Buck Mountain vein is also operated, near the eastern extremity of the Black Creek basin, under the same peculiarities existing at the old mines.

About six miles to the west of Buck Mountain are the Stockton mines, on the Hazleton Railroad. A branch of the Hazleton road connects the Buck Mountain mines at Clifton with the main Hazleton road, at its intersection with the Beaver Meadow, a short distance above Weatherly.

FIG. 47.

MAMMOTH, OR E, AT DIAMOND MINES, HAZLETON.

Above the Stockton, in the vicinity of Hazleton, are the Diamond mines of A. Pardee & Co., Old Hazleton, Laurel Hill No. 1, Laurel Hill No. 2, and Hazleton No. 3. Farther west are the Crystal Ridge and Cranberry collieries of A. Pardee & Co. Succeeding these are the Mount Pleasant mines of Taggart & Halsey, and near the end of the main basin are the Ashburton mines, recently opened.

In the greatest part of the basin there are two, and sometimes three, synclinals. Even at the Diamond mines, where the basin is considered as single, or existing in a wide, deep, and unbroken synclinal, there is a sharp, wedge-like anticlinal, that folds back in a peculiar manner over the north dip in such an unusual and reversed condition as to make the bottom slate of the one the top slate of the other.

It will be noticed in the sections of the Mammoth which we give at various localities, that this vein varies considerably in composition or character, but throughout the Lehigh region is nearly uniform in size. It generally contains from 20 to 30 feet of workable coal, and is almost invariably reliable, or in good condition and extremely productive.

The amount of coal annually sent from the Hazleton basin, and principally from the vicinity of Hazleton, is nearly, if not fully, a half-million tons.

A. Pardee & Co. are the largest miners and shippers of coal in the anthracite region, as a private firm; and, in connection with the Hazleton Coal Company, which is nearly synonymous, or Pardee & Co., the firm owns or controls 42 miles of railroad-track, 17 first-class locomotives, 1800 coal-cars, and does the shipping business of the Hazleton and Big and Little Black Creek basins, or nearly one million tons per annum.

BIG BLACK CREEK COAL-BASIN.

This basin is now tapped or opened at two different points. First, at its eastern extremity, by the Buck Mountain Coal Company, whose planes descend into the Black Creek basin, or over Council Ridge from Clifton. This company has two slopes in operation to the bottom of the basin, which is here shallow and does not contain over 150 feet of coal measures.

The second avenue of the coal-trade from this valley is through the Council Ridge tunnel, which is 1023 feet long, over the Lehigh Luzerne Railroad. This road leaves the Hazleton road at the board-yard, some distance below Stockton, and passes through the tunnel to Jeddo, and thence down the valley of Big Black Creek to Ebervale and Harleigh, and from Harleigh it is continued around the western point of Black Creek ridge to Milnesville in Little Black Creek.

From the mouth of the tunnel a branch of this road turns up the valley to Eckley, which is one of the most handsome, attractive, and orderly mining villages in the coal-regions. At Eckley are the mines of Messrs. Sharpe, Weiss & Co., to whom, in fact, the village owes its existence.

Here the basin of Big Black Creek is three-quarters of a mile wide and divided into four synclinal troughs, or undulations, which increase in breadth and depth from the south to the north side of the basin. The mines at Eckley are located on the "saddle," or anticlinal, between the two first or southern basins or synclinals, and consist of two slopes, one in each basin. That in the first basin is on the south dip, with an angle of 30°, and that in the second basin is on the north dip, with an angle of 20°. Each is 200 yards deep, and the basins they penetrate are, respectively, 125 feet vertical in No. 1, and 275 feet in No. 2,—the vertical depth varying with the undulations of the surface.

The capacity of these mines is about 125,000 tons annually. During the year 1864 nearly 110,000 tons were produced.

Section of Coal Measures at Eckley.

Fig. 48.

	Ft.	In.
Surface, 125 to 300	200	0
Mammoth, E	30	0
Slates and sandstones, Small Seam of Ore	150	0
Wharton, D	8	0
Slates and sandstones	100	0
Coal, C	1	6
Slates and sandstones	60	0
Buck Mountain B Coal	20	0
Slates and sandstones	40	0
Coal, A, in conglomerate	1	6

It will be noticed that we give the size of the Mammoth in the section through the coal measures as 30 feet at Eckley, while in the section of the vein it is less than 20 feet. This difference is explained by the fact of the vein being thicker in the deep northern basins of the valley than in those now operated on the south side.

Fig. 49.

Fig. 49 is a vertical section through the measures at Harleigh, in the Big Black Creek basin, furnished by Alexander Silliman, Esq. The surface measures above the Mammoth are barren of coal, as usual throughout the Lehigh basins, and are not given in the section. Their thickness is from 150 to 300 feet. The coal-basin here is divided into two subordinate basins or synclinals, with an aggregate breadth of 800 yards.

The distance between E and D in the section is here 210 feet; but this varies considerably farther up the valley, and at Eckley is only 150 feet. The lower veins are thicker in the Black Creek region, generally, than in any other portion of the Lehigh basins.

The Wharton or Skidmore, D, is here 12 feet thick, and a nameless vein, C, which is generally small, is 10 feet in thickness. The Buck Mountain B is not as large as it is found at the old Buck Mountain mines, at the Grand Tunnel in the Wyoming valley, or at New Boston, but is larger than its average size, generally, in the Lehigh basins.

The Mammoth is here 30 feet thick, and contains 20 feet of workable coal, with 10 feet of rejected or unworkable mine. The top, nine feet, is not worked. It is very productive, and mined with economy. The capacity of the Harleigh mines is 100,000 tons annually; their pro-

VERTICAL SECTION AT HARLEIGH, IN BIG BLACK CREEK BASIN.

duction during 1864 was 60,793 tons. They were operated last year by Messrs. Silliman & McKee, but have since changed hands, and are now (1865) operated by the Harleigh Coal Company.

The mines at Ebervale are operated by Messrs. Stout, Van Winkle & Co., lessees on lands of the Union Improvement Co. They have three slopes: two on the south dip and one on the north dip of the Mammoth.

The next in operation above Ebervale are the Jeddo mines of J. B. Markle & Co., also on the lands of the Union Improvement Company. Here there are three slopes in operation: two on the Mammoth, and one on the Buck Mountain vein,—all on the south dip.

Commencing at the lower end of the Big Black Creek basin, we find five colliery establishments in the valley, viz.: Harleigh, Ebervale, Jeddo, Eckley, and Buck Mountain mines,—the last being on the waters of Sandy Creek, flowing into the Lehigh to the east, and the former on the waters of Black Creek, which flow west and north into the Nescopeck and thence into the Susquehanna. The amount of coal mined by the Lehigh operators respectively will be found in the accompanying table.

Fig. 50.

MAMMOTH AT HARLEIGH, IN THE BIG BLACK CREEK BASIN.

LITTLE BLACK CREEK BASIN.

In the Little Black Creek basin there is only one operation, which is at its western end and is known as Milnesville. The name of J. Fields appears as the operator on three slopes: two on the north and one on the south dip of the Mammoth. This basin is but little developed. It is probably about half the area of the Big Black Creek basin, which is about 12 miles long and with an average breadth of half a mile, containing six square miles of coal formation; while the Little Black Creek basin is only about seven miles long by 500 to 800 yards in breadth, containing two and a half square miles of coal formation, "more or less."

The Lower Black Creek Basin lies to the west of the two basins just mentioned, and on the Black Creek, below the junction of the big and little forks of the same, from which are derived the names of the coal-basins over which they flow. This lower basin is about ten miles long by 800 yards wide, and contains about five square miles of coal formation. There is some doubt of the existence of the Mammoth in any part of the Lower Black Creek basin, but all the lower veins are found in large proportions and in good condition,—the Buck Mountain bed, in some places,

being equal in size to the Mammoth. The veins have been generally proved in this basin, but no collieries have been established, and no avenue yet exists for the transportation of its coal. The Lehigh Luzerne Railroad is projected for extension farther down the stream, and will soon open the upper end of the lower basin. Other avenues for the transportation of its coal have been projected: one from Berwick, on the Susquehanna, up the Nescopeck and Black Creeks, and another from the lower or western end of the basin over the mountains to the Catawissa Railroad, which is but a short distance from this point.

The Green Mountain basin is a comparatively small body of coal, lying on the head of Sandy Creek, which flows into the Lehigh. It may be equal in size to the Little Black Creek basin, but it is yet undeveloped, and but little is known of its character or formation.

The remaining small basins of coal on the lower branches of the Big Black contain only the lower veins, and these to a limited extent; but such coal as exists appears to be good, and even one of those small basins, with but a single square mile of coal formation, and containing only the lower or Buck Mountain bed,—say 12 feet thick,—would produce enough to last a single colliery, producing 100,000 tons per annum, 100 years or more.*

COAL AREAS OF THE LEHIGH BASIN.†

	Sq. Miles.
Hazleton Basin, 14 miles long, ¾ wide	10
Beaver Meadow, 11 " " ¾ "	8¼
Big Black Creek, 12 " " ½ "	6
Little Black Creek, 7 " " ⅜ "	2½
Lower Black Creek, 10 miles long, ½ wide	5
Green Mountain Basin, 7 miles long, ⅜ wide	2¼
Other small basins	3
Total area	37

Production of the Lehigh Basins in 1864.

A. Pardee & Co., Hazleton Basin	210,902
Honeybrook Coal Company, Beaver Meadow Basin	146,563
Packer & Co., Hazleton Basin	143,090
Sharpe, Weiss & Co., Big Black Creek	109,983
J. B. Markle & Co., " "	153,563
Spring Mountain Coal Company, Beaver Meadow Basin	102,881
German Pennsylvania Coal Company, Beaver Meadow Basin	78,402
Harleigh Coal Company, Big Black Creek	60,793

* Recent developments indicate the existence of E, or the Mammoth, in some of these eastern basins.

† The areas of these basins are computed as their maximum extent. The angles of the dips are generally high. The maximum coal area is, therefore, greater than that given above, and may exceed 50 square miles.

Buck Mountain Coal Company, Big Black Creek*................	73,534
Smith's Spring Mountain, Beaver Meadow Basin.................	53,110
John Fields, Little Black Creek..	60,214
William T. Carter & Son, Beaver Meadow Basin..................	49,181
Ebervale Coal Company, Big Black Creek..........................	52,137
Taggart & Halsey, Hazleton Basin.....................................	59,891

Recapitulation.

Hazleton Basin..	448,383
Beaver Meadow Basin...	430,137
Big Black Creek Basin..	415,010
Little Black Creek Basin..	60,214
	1,353,744

* About one-half of this amount is from the Big Black Creek basin, and the other from the Hazleton basin.

CHAPTER X.

THE MIDDLE ANTHRACITE COAL-FIELD.

Divisions of the Coal-Field—Transverse Section—Mahanoy and Shamokin Regions—Locust Mountain—Broad Mountain—Mahanoy Mountain—Mahanoy Basins—Primrose Bed—Mammoth Enlargements—Inverted Dips at McNeal Coal Company, and at Shenandoah City—Vertical Section at Mahanoy City—Preston Sections—Freaks of the Locust Mountain—Locustdale—Ashland—Coal Properties or Estates—Production—Shamokin Region—Transverse Section—Coal-Seams—Twin Veins—Trevorton—Vertical Section at Shamokin—Identity of the Coal-Seams—Avenues to Market—Productions.

The Middle coal-field is divided by the Locust Mountain, and forms two distinct regions. The eastern portion, lying south of Locust Mountain, is drained by the Mahanoy Creek, and is denominated the Mahanoy region; while the western portion, lying north of the Locust Mountain, is drained by the Shamokin Creek, and is known as the Shamokin region. Both streams empty into the Susquehanna,—the Shamokin at Sunbury, and the Mahanoy a short distance below, at Port Trevorton.

The area of the Middle coal-field is computed at 91 square miles; the eastern, or Mahanoy region, containing 41 square miles, and the western, or Shamokin region, 50 square miles. The length of the first is about 25 miles, with a mean breadth of less than 2 miles; and the length of the latter is 20 miles, with a mean breadth of about 2½ miles.

The amount of coal contained in the two regions may be about equal, notwithstanding the difference in area. The basins are deeper, though more narrow, and, consequently, the angles of dip are also greater, in the Mahanoy. This increases the area of the coal above the extent of surface under which it is basined. The coal-veins are also thicker and more productive on the Mahanoy than the Shamokin, as the accompanying sections indicate.

MAHANOY REGION.

Figure 51 is a transverse section of the Mahanoy coal-basins, including the Broad Mountain or New Boston basin; which, however, does not properly belong to this region, and will not be considered in connection with the Middle coal-field, but rather with the Broad Mountain and Mine Hill basins of the first or Southern coal-field.

In this illustration, figure 51, *a* is the location of the New Boston basin on the Broad Mountain; *b* is the position of Mahanoy City, in the upper

part of the Mahanoy Valley; *c* and *d* represent the locations, respectively, of Middle Mahanoy and North Mahanoy, or the second and third basins of the Mahanoy Valley. The Shenandoah basins are denoted by *e*, and the

FIG. 51.

TRANSVERSE SECTION, MAHANOY BASINS.

sharp, inverted anticlinals of the north dips: this, however, is also a trait of the formations at the south, in the vicinity of Mahanoy City. The view is presented looking west,—*a* being south, and *e* north. The Broad Mountain here bounds the coal-field on the south side, and the Locust Mountain on the north side.

Farther west, or down the valley, the Mahanoy Mountain starts out from the Broad Mountain and forms the south boundary of the coal-field; but at the western extremity of the Mahanoy region the Locust Mountain—crossing the coal-field from its north side—intersects the Mahanoy Mountain, and becomes from this point the southern instead of the northern boundary of the coal-field. The Shamokin Mountain forms its northern boundary from the vicinity of Centersville, or a point nearly opposite Ashland, where the Locust Mountain enters or commences to cross the coal-field. The Locust Mountain divides the field into its eastern and western divisions or regions. It is the northeastern boundary of the Mahanoy basins, and the southwestern boundary of the Shamokin basins.

The undulations of the Mahanoy formations are frequent and abrupt; the basins are deep, and the dip of the veins is frequently over 45°, and sometimes reversed, or both north and south dips are in the same direction, as illustrated in the vicinity of Shenandoah City. But these inverted dips also occur in other portions of the region, and, we believe, almost invariably on the south sides of the basins, as we find them in the Southern field, and particularly in the Pottsville district. Generally the south dips are regular, but range from 30°, or less, up to 60°. From 30° to 45°, however, is about the mean of those south dips. There is an exception to these inverted north dips along the base of the Broad and Mahanoy Mountains, or on the southern extremities of the field. They occur locally in the interior of the field, or in the central basins, and are not general even in them.

A large amount of coal lies above water-level in the Mahanoy basins. The frequent undulations of the measures bring the veins to the surface in

successive anticlinals; and the hills or ridges within the coal-field being comparatively high and undulating in conformity with the coal measures, the coal is frequently exposed above water-level, and made available by the numerous water-courses crossing their strike and denuding the coal-strata. In this respect there is a great uniformity between the Mahanoy and Schuylkill basins; and in the general form and dip of the veins and basins themselves there is a like conformity. A more general likeness exists in form and feature, both of surface and coal-formation, than even between the eastern and western portions of the Middle coal-field. The Mahanoy Valley or field is narrower than the Schuylkill, and the hills appear to be higher; but we think the appearance is deceptive, and that there is really little difference except in the item of breadth.

In regard to the veins there is more difference. The lower veins in the Mahanoy are generally larger and more productive than they are in the Schuylkill region. The Mammoth vein and those immediately above it do not vary much from the same veins here, except in their uniformity and perhaps greater purity. But the veins below the Mammoth are greatly in excess of the same beds in the central portions of the Schuylkill region, and are more in conformity with the beds of the Lehigh basins.

Below we give two sections of the Primrose or G, one being the general type of the Mahanoy, and the other of the Schuylkill.

FIG. 52.

FIG. 53.

PRIMROSE G VEIN AT TAMAQUA.

PRIMROSE G, AT HILL & HARRIS'S, MAHANOY.

The average size of the Primrose appears to be about 12 feet in the Mahanoy basins. At some points it is larger, and generally in very good condition.

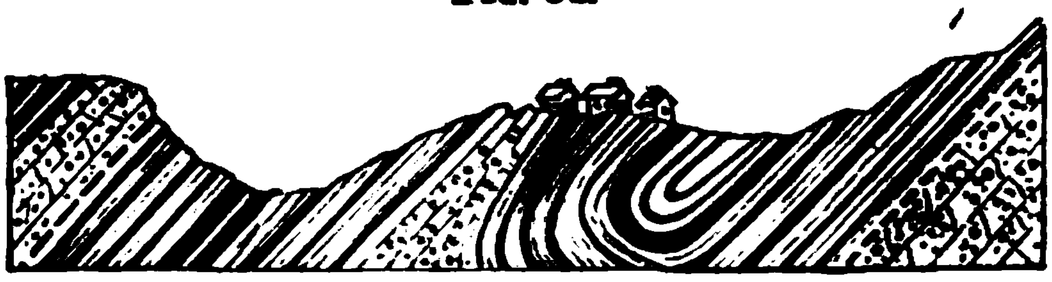
Mr. Francis Daniel, of the McNeal Coal Company's Mines, in the North

Mahanoy basin, gives the Primrose vein as 16 feet thick in that locality, with 15 feet 6 inches of pure coal, and not over 6 inches of slate.

An enlargement of the Mammoth takes place at this point, which is nearly equal to the famous Lehigh quarry, and similar to the Mammoth at Miller's Shenandoah City colliery, or at the New Boston mines on the Broad Mountain, of which we have given an illustration in the description of that basin.

These great enlargements in the Mahanoy basins are generally on the north dips, where the veins are perpendicular and often double. We give the two sections of the Mammoth as proved in these two collieries. At the Shenandoah City colliery the operations are on the inverted north dips, and an enormous thickness of coal here exists in a very limited thickness of measures. The veins are nearly perpendicular, but dipping to the *south*, though they are partly north-dipping veins. They are in the second or south basin, in the Shenandoah Valley. Of course, all the veins in the basin have a south dip in consequence, but the north dip is doubled back on the south dips, so that all the veins in the basin have the appearance of south-dipping strata. The accompanying illustration, figure 54, will clearly express this peculiarity.

FIG. 54.



COAL BASINS AT SHENANDOAH CITY.

This peculiarity, we may here state, is not confined to this locality. It is found in the vicinity of Mahanoy City, at the McNeal colliery, north of Locustdale, below Ashland, and in many other parts of the Mahanoy region. It is also a form of basin frequently met with in the Pottsville district, and, in fact, throughout the Southern coal-field. It is not generally favorable to the condition of the coal or the economical working of the veins; but sometimes the coal is found unaffected in quality by the increase in quantity, and the vein in good workable state, though greatly changed from its original and ordinary position.

This feature of the anthracite formation is but imperfectly understood by our miners, and frequently occasions much trouble. It gave an imaginary existence to the mythical jugular, and men are still found who are willing to spend their money on the strength of their faith in its reality, though abundant proof has existed during the last ten years that the jugular is simply an enlargement of the Mammoth, on the principle set forth.

This "vexed question" will be more fully explained under the head of "faults and irregularities."

Section of the Mammoth at the McNeal Coal Company's Mines, as given by Mr. Frank Daniel.

	Ft.	In.
Top slate	0	0
Bone and slate	1	0
Coal	2	0
Slate and bone	1	0
Coal	2	6
Slate and bone	1	6
Coal	2	0
Slate and bone	1	0
Coal	2	6
Slate	0	6
Coal	2	0
Slate and bone	1	6
Coal	3	0
Slate and bone	1	6
Coal	2	0
Bony coal	1	0
Coal	1	6
Slate	0	6
Coal	8	0
Slate and bone	3	0
Coal	3	6
Slate	2	0
Coal	7	0
Workable coal	36	0
Bone and slate	14	0
Total	50	0

Section of the Mammoth at the Shenandoah City Colliery, as given by Mr. Jonathan Wasley.

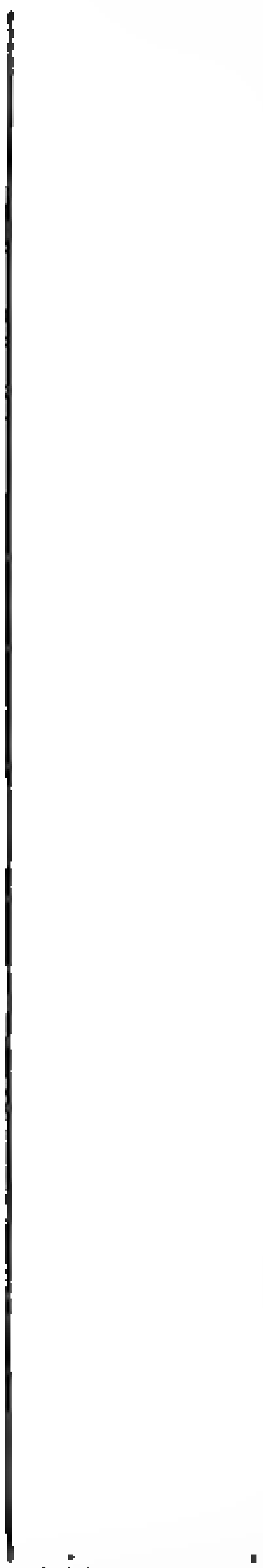
	Ft.	In.
Top slate	0	0
Coal	7	0
Slate	1	6
Coal	4	0
Slate	0	4
Coal	8	0
Charcoal "Mother"	1	3
Coal	8	0
Bone	0	1
Coal	8	0
Slate and bone	0	6
Coal	1	0
Bone	0	1
Coal	9	0
Bone	0	½
Coal	2	0
Bone	0	½
Coal	5	0
Bone, parting	0	0
Coal	8	0
Parting	0	0
Coal	7	0
Workable coal	67	0
Slate and bone	3	6
Total	70	6

It will be noticed on the accompanying map of the anthracite coal-fields that a slender point of the Mahanoy basins extends far to the east and parallel with the Lehigh basins, and may, perhaps, more properly belong to that group than to the Middle coal-field, though the entire cluster is often included in this field. This point or slender finger of coal extends across the Catawissa Railroad towards the extremity of Head Mountain. A considerable body of coal exists in the most eastern basin, which is several hundred yards in breadth and probably seven hundred feet in depth. Messrs. A. Grey & Co., of Wilkesbarre, commenced to develop this basin in 1864.

The coal on the south dip is imperfect, and the vein—probably the Buck Mountain—stands perpendicular,—the thickness of which was not known

during our visit, but must have been over 20 feet. If the coal prove good, there is a considerable body of it in the basin.

FIG. 55.



VERTICAL SECTION AT MAHANOY CITY.

Farther towards the centre of the field, and on the west side of the Catawissa Railroad, two narrow parallel basins have been proved on the lands of Alter & Stephens. Two of the lower veins are here found in workable condition.

It does not appear that the coal-basins are continuous at the eastern extremity, though the middle fork of the Mahanoy formation extends throughout. The conglomerate comes to the surface, however, at several points on this slender extension, and interrupts the continuation of the coal-basins. The extension is therefore formed by a succession of narrow and parallel basins, containing only the lower beds, which deepen, widen, and become continuous as they approach the waters of the Mahanoy.

There are five principal basins across the Mahanoy end of the Middle coal-field in a line from New Boston to Shenandoah City. Within these basins are several smaller undulations or rolls, as shown in the basin *b*, figure 51; but those rolls are local and have no great length of strike or axis; and the principal basins also change in a westward direction, and become merged in basins of greater depth and extent. The five synclinals of figure 51 decrease to three, four, or five miles down the valley, and the four anticlinal ridges decrease to one in the vicinity of Girardsville; but though the ridges which mark the anticlinals in the upper portion of the valley become depressed or die out, the axis of one is preserved. In plain mining-phrase, there are five basins and four "saddles—besides small subordinate rolls—in the section given from New Boston to Shenandoah (not including the former); while at Girardsville there are only three basins and two "saddles," besides several minor undulations.

Figure 55 is intended as a type of the measures in the vicinity of Mahanoy City, or on the transverse line of figure 51. Owing to the recent development of this region, some confusion exists in relation to the veins. The Buck Mountain, whose natural position is B, appears as C in the column. We are under the impression, however, that the veins are right and we are wrong, as well as the mining engineers of that section. But at

present it is impossible to place the lower veins where they belong. That there is some error here seems more probable than that there is a displacement, since the veins assume their proper relation in the more developed portions of the region, as may be noticed in the Locustdale section, west of Ashland.*

On the Preston Coal and Improvement Company property, below Girardsville, the Mahanoy and Shenandoah basins unite, forming three deep, comparatively wide, and uniform basins. The Locust Ridge and Bear Ridge anticlinals become depressed in this locality, and, instead of the conglomerate appearing on their axis, the lower veins pass over them and form a continuous bed from the Mahanoy to the Locust Mountain.

The Mammoth on this property is in good workable condition, about 25 feet thick. This vein is generally most productive and reliable when in its natural dimension, which varies from 20 to 35 feet. Any great increase or decrease above or below these sizes generally, though not invariably, diminishes its value and productiveness. The Buck Mountain, Skidmore, or North Vein, as it is locally called, also exists in its best

TRANSVERSE SECTION OF THE MAHANOY COAL-BASINS AT PRESTON.

Figure 56 is a transverse section from the Locust to the Mahanoy Mountain on the Preston estate, a little to the west of Girardsville. The Mahanoy Mountain is on the left and the Locust on the right of the section. The observer looks west. *a*, *a*, are drifts on the Mammoth and Buck Mountain, and supply the Preston colliery No. 1, the breaker of which is located at *d*; *b* is Preston colliery No. 2, which is supplied by slope *c* on the Mammoth; *e* is a water-level tunnel, which drains the slope *c*; *g* is a small basin, on which the Folkton colliery is located. This basin terminates a short distance west, and the workings of the Folkton colliery, passing round the west end of the middle basin, enter the left basin under *h*.

The Hunter colliery, *o*, is located about one mile west of the Folkton colliery, and is supplied by tunnel *h*. The Folkton colliery is not located on the section, but the tunnel at *i*, apparently under the Hunter colliery, though nearly one mile east, drains the slope of the Folkton. The letters A, B, C, D, E, F, G, denote the white-ash seams; H, I, J, and K, the upper or red-ash seams.

* Since the above section was made, we are informed that recent developments have demonstrated the fact that the veins here are "in place," and the one we have called C is really B.

dimensions and most productive condition; while the Primrose and one or two overlying veins are favorably developed.

The coal-field here is nearly two miles wide, which is rather less than its breadth five miles farther east; but the amount of coal is nevertheless greater.

There is some confusion in the identity of the veins and the application of names in this section of the coal-field. But we have found so much general consistency in the relative positions of the main coal-veins, and so much uniformity in the veins themselves, that we do not hesitate to name them here, as elsewhere, in their general order. There are, however, exceptions taken to this order by some of our engineers, as represented in the columnar sections which we have given. C of our nomenclature does not exist in their sections of this portion of the coal-field, unless it exists as the Big North Vein. In that case B, or the original Buck Mountain, has grown poor and lean at the expense of C, which has proportionally increased in bulk. We cannot accept this theory for fact, since we find the true relations restored in the neighboring basin of New Boston, where the Buck Mountain vein B exists in its proper position and natural condition. The altered position of this vein may be better understood by a reference to figure 55 in the Mahanoy vertical section, where C is evidently the Buck Mountain vein, though occupying a position much above its proper location in the coal measures.

The accompanying sections of the several veins in the Preston tract will testify strongly as to their identity. The Mammoth, of course, there can be no mistaking: it is the superior bed of the anthracite fields, and so preeminent that no other vein can approach in magnificence of size or production.

The Buck Mountain, below the Mammoth, is the next in size and productive character; while the Primrose is the most important seam above the Mammoth. Within this range of the coal measures there are seven workable veins, including the three named, all of which belong properly and generally to what are known as the white-ash coals; though the lower bench of the bed B is invariably *red-ash,* and sometimes of a deep-red color, as noticed in our description of the original Buck Mountain vein, page 194, Chapter IX.; while the Primrose is generally considered as a pink or gray-ash. The Primrose bed, or G, is generally from 12 to 14 feet thick on this property, and is sometimes found pure, without slate or bone. It varies, however, from 10 to 20 feet in thickness, and frequently contains small partings of bone.

The Mammoth bed, E, is here about 25 feet thick, and in very fine condition, as shown by the accompanying section.

The Skidmore bed, D, is not fully developed on this property; and we could not get a perfect section.

Prof. Lesley, in his report to the company, marks the Skidmore as the "Ten-foot," and calls B the Skidmore, which is also a mistake fallen into by Mr. Sheafer, from the imperfect development of the locality and the region generally, as both these gentlemen are eminently practical, and familiar with our coal-fields.

FIG. 57.*

Bed C has not been developed here, but it undoubtedly exists. We have before stated that this is a comparatively small and irregular seam, but a persistent one, and entitled to a place in our columnar sections.

Bed B, the old Buck Mountain or "North vein," as here locally known, is developed in fine condition, as shown by the section. It ranges from 15 to 20 feet in thickness, producing most excellent coal. We doubt if this bed exists in any other locality in better condition.

A is found below B in its proper size and condition. It is known as the "rough vein," and is about 50 feet below B, in the conglomerate.

The vertical distance from B to E is about 250 feet, —perhaps more; thus giving ample room for C and D. Above the Mammoth 150 to 200 feet lies the Primrose, or G; and between them is the small seam F, or the Holmes. The order in which the seams are distributed may be seen in figure 56, which conform to the positions and order of our general sections. The peculiarity of the formation, however, gives more red-ash seams here, perhaps, than in any other portion of the Mahanoy region, as may be noticed in this transverse section.

One of the Mahanoy basins terminate west of Preston. The main or south basin is the only one continued to the extremity of the Mahanoy region, where the Mahanoy and Locust Mountains intersect. The north basins die out about midway between Locustdale and the western termination of the south basin, or overlap the Locust Mountain.

We may here remark the existence of the third basin at Preston as drained by the Big Mine Run, opposite Ashland, which may be called the Centreville basin in that vicinity; but this basin properly belongs to the Shamokin region, rather than to this portion of the Mahanoy

BEDS G, E, AND B, AT PRESTON.

* We proposed to give a section of the Skidmore in this connection, but have been unable to obtain it.

since they are divided at Locustdale by the Locust Mountain, and drained by different streams running reversely. But on the Big Mine Run and on the Preston property the Locust Mountain becomes simply Locust Ridge, which is overlapped by the coal, and the mountain-range north of Locust Ridge there receives the name of Locust Mountain. The same occurrence takes place west of Locustdale, or at Locust Gap, where the coal again overlaps the dividing ridge, as it does to the east. The name applied to this dividing ridge is geologically and topographically a misnomer. It takes its rise at the eastern end of the basin, and divides the Shenandoah from the Mahanoy, as the Locust *Ridge*, and runs parallel with Locust Mountain as far as Big Mine Run under this title, and nearly as far as Mt. Carmel, in fact. But from Big Mine Run this ridge, which rises and sinks alternately, is dignified with the name of "Locust Mountain," though that mountain really exists a mile to the north, and continues in a direct line many miles to the west, parallel with the ridge which from Big Mine Run usurps its name. But, more singular still, on crossing the coal-field these hills obtain a title to the Mahanoy Mountains; and that long range which bore the name of Mahanoy appropriately, resigns it to this usurping ridge.

The topography of the field does not justify this change of names, and the geological formations are distinctly opposed to it, since the axes of both synclinals and anticlinals are parallel and cross the ridge obliquely where it traverses the field. The name may have been locally and primitively applied; but it is nevertheless a misnomer, and tends to confuse both the topography and geology of the section.

Figure 58 is a representation of the field at or in the vicinity of Locustdale. It is generally considered as composed of two basins; but the north basin is really divided into two distinct basins or synclinals. We may

FIG. 58.

TRANSVERSE SECTION AT LOCUSTDALE.

here notice, in order to make our description plain, that the Locust Ridge, on the right, divides the Mahanoy from the Shamokin region at this point by an unusual elevation of the conglomerate and red shale; while both

east and west, at Locust Gap and Preston, this elevation is depressed, and the coal overlaps the mountain, forming a continuous field. The north basin is here separate and distinct from the Mahanoy region, and forms the south basin of the Shamokin region, as illustrated in figure 61, representing the West Mahanoy and Shamokin regions, *c* being the Locust Mountain, so called.

In the section as above given, we have not represented a small roll on the southern outcrops, as developed at Bancroft's Pioneer Colliery, and referred to in a previous page. It is here insignificant, and evidently "dying out," or disappearing from the basin, and is not sufficiently developed to justify an accurate delineation.

The illustration we have given of the Locustdale basins, in figure 58, is in strict accordance with present developments, but does not strictly agree with the opinion of those who are practically familiar with the basin. In their opinion, the basin is much deeper than portrayed; and this opinion is based on sound principles,—the increasing angle of dip as the workings descend, and the angle of the strata in the centre of the basin, denoting that the dip of the veins is greater towards the centre of the basin than on its outcrops.

We have given the angles as now developed,—45° on the south dip, and 70° on the north dip; but the probability is that an average of 70° would approximate the general inclination. The basin, therefore, instead of a thousand feet of perpendicular depth, is, in all probability, over 2000 feet vertical from the surface.

We find in this conformity one of the conditions of that depression and lateral contraction which we endeavored to illustrate in figure 6. It would be impossible for the immense mass of coal existing in this deep basin to have been created on angles of such great acuteness. The coal must have been formed under far different circumstances. It is uniform in character and quality; while the veins are in their best workable dimensions.

Figure 59 illustrates the workable veins of this basin. They are all found "in place," and are consistent with the formations of other regions. The Buck Mountain vein, or B, is in good size and condition, and the Skidmore, D, is also finely developed. This vein ranges from 7 to 12 feet in thickness, but its best or most productive and reliable thickness is 10 feet. The Mammoth here is only 25 feet thick, but is uniform and unusually free from impurities, as shown by figure 60. As before remarked, this great bed is generally most productive and reliable when within its medium dimensions, or from 20 to 35 feet in thickness. At Locustdale its conditions are extremely favorable, and the natural advantages offered have been made practically available by the skill and experience of the management.

The mode of mining known as the "run" is here adopted with much

economy. The solid nature of the superincumbent strata, and the more immediate top slate, render this mode available here in an eminent degree, while the purity of the vein enables the miners to send to the surface the entire production. When the angle is over 40°, and the conditions are as favorable as at this locality, the mode known as the "run" is the most economical that can be practised. But when the angle is too low to permit the coal to descend the dip of the vein by its own gravity, or the top slate is "rotten," and falls with the coal, or when the coal itself—the vein—is impure, this mode cannot be made use of to advantage. In the first place, because the coal will not "run;" and, in the second, the impurities falling and mixing with the coal render the whole impure and unfit for market. We shall notice this mode more fully, in connection with other modes, under the head of Economical Mining; while a more extended notice of the Locustdale colliery and improvements will be found in the Appendix, as we consider them the most perfect and extensive mines in the anthracite regions.

Fig. 59.

VERTICAL SECTION AT LOCUSTDALE.

Figure 60 illustrates the Mammoth in this locality, and is a general type of this great bed in the western portions of the Mahanoy region. It is, however, thicker, and perhaps equally pure, in the vicinity of Ashland and on the Locust Mountain Coal & Iron Company's property generally. The large and valuable estates owned by the Preston Coal & Improvement Company, the Locust Mountain Coal & Iron Company, the Brock estate, the Locustdale Coal Company, and the Black Diamond Coal & Iron Company, are among the most valuable coal properties in the anthracite regions. They are located in the western end of the region; which, we think, is generally more reliable than the eastern end, though the veins are frequently larger in that direction, as noticed in several localities. But we cannot justly make comparisons, since the eastern section is less developed than the western, while the coals of each enjoy a high reputation for their fine appearance and excellent quality.

We have found much difficulty in obtaining data in relation to the colliery establishments, but think we are generally correct in the classification of names and productions for 1864. The region is not naturally divided into districts, and the coal pursues no special avenue to market. There

are four railroad lines leading from the Mahanoy region. The first, commencing at the western end, is by the Mine Hill & Schuylkill Haven Railroad and planes, which ascend and cross the Broad Mountain some distance below Ashland. The second line is the Mahanoy & Broad Mountain Railroad and planes, which ascend and cross the Broad Mountain some distance above Girardsville, and descend by way of Mill Creek and St. Clair. The third line penetrates to the eastern end of the basin from the direction of Tamaqua, through the Hossasock Mountain by tunnel. This line, the East Mahanoy, connects with the Catawissa a short distance above Tamaqua, and terminates at or near Mahanoy City, a distance of thirteen miles.

FIG. 60.

SECTION OF MAMMOTH AT LOCUSTDALE.

These lines are now under the control and management of the Philadelphia & Reading Railroad Company, to whose line they are large feeders.

The fourth line is the Lehigh & Mahanoy, and extends from the Black Creek junction with the Beaver Meadow Railroad to Mount Carmel, *via* Shenandoah and Centreville, with a branch to Mahanoy City. This line promises to be an important outlet, as it opens the market direct by rail to New York. This road is 40 miles in length, and has some 14 or 15 miles of connecting branches to the mines.

LIST OF THE MINERS AND PRODUCTION OF THE MAHANOY REGION, 1864.*

	Tons.		Tons.
Repplier & Moodie	126,000	Hill & Harris	35,654
Locustdale Coal Company	113,641	Suffolk Coal Company	28,106
Bast & Pearson	107,726	F. J. Anspach & Co.	22,141
Union Coal Company	105,040	Thomas Gorman	21,845
Connor & Patterson	81,097	John Jones	20,132
St. Nicholas Coal Company	70,474	John Anderson & Co.	14,951
R. Gorrel & Co.	68,918	C. Garretson	11,275
Preston Coal & Impr't Co.	68,218	Althouse & Focht	10,764
S. M. Freck & Co.	67,138	Mahanoy Coal Company	7,647
Glennville Coal Company	67,088	Wm. H. Shaefer	7,239
Bancroft, Lewis & Co.	56,706	Carter, Sheoner & Co.	2,751
Black Diamond Coal Co.	56,574	J. R. Cleaver & Co.	1,882
A. C. Miller & Co.	55,028	F. B. Kearcher & Co.	1,093
Gilberton Coal Company	53,085	East Mahanoy Coal Co.	743
McNeal Coal Company	43,000	Dengler & Robinson	214
Wiggan & Treibles	42,634	Am't sent over P. & R. R. R.	1,425,068.
J. & E. Silliman	39,559		

* The location of the mines respectively producing this coal will be found on our map of the coal-fields. There are changes in names and firms which will also be noticed.

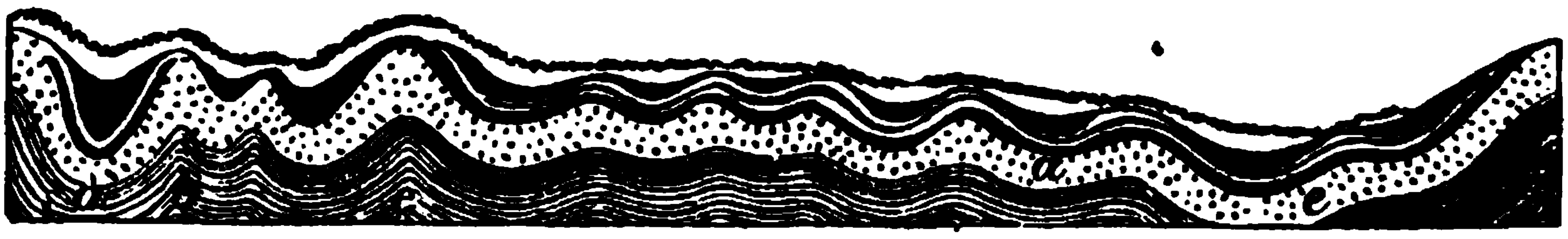
In addition to the above, 132,808 tons were sent from this region, *via* the Lehigh & Mahanoy Railroad, direct to New York, by the following firms:—

	Tons.
J. & O. O. Bowman	39,212.01
Alfred Lawton & Co.	37,206.06
Rathburn & Caldwell	12,669.11
M. Barry & Co.	2,385.12
McNeal Coal Company	31,076,11
Fowler & Huhn	230.06
Shoemaker & Co	267.12
S. & P. Brooks	104.19
W. F. Patterson	9,644.15
J. & E. Silliman	10.00
Amount sent over the L. & M. R. R.	132,808.05
Amount above stated	1,425,068.02
Total from Mahanoy region in 1864	1,557,876.05

THE SHAMOKIN REGION.

This, as we before stated, is the western end or portion of the Middle coal-field, and is perhaps the "largest half," though the field is nearly equally divided by the Locust Ridge or so-called Mountain. The eastern or Mahanoy region is estimated to contain 41 square miles of coal area; while the western or Shamokin region is put down at 50 square miles of coal area, —the total area of the field being 91 square miles. This portion of the field is wider in its centre than the eastern portion, and the undulations are more numerous, but they are not generally so abrupt or their angles so great. There are exceptions; but the basins, as a rule, are neither as deep nor as steep in their dips as those of Mahanoy. The accompanying illustration, figure 61, will portray this difference as compared with figure 51.

FIG. 61.



TRANSVERSE SECTION FROM MAHANOY MOUNTAIN TO SHAMOKIN MOUNTAIN.

Figure 61 represents a section across the western end of the Mahanoy region and the central portions of the Shamokin region. The Mahanoy Mountain is on the left; *a* is the Locustdale basin, west of that point; *b* is the Bear Ridge anticlinal; and *c* the Locust Ridge, or so-called Mountain; *d* is the central or deep basin of the Shamokin region; and *e* the location of the town of Shamokin; while the mountain on the right end of the section is the Shamokin Mountain. The breadth of this portion of the field, or the Shamokin region, is from *c*, or the Locust Mountain, to the Shamokin Mountain, a distance of three miles or over.

Though the basins of this section are less in depth than those of Mahanoy, and more uniform in dip, with lesser angles of inclination, their "strike" or prolongation on uniform axis is much less regular and reliable,

and the size and character of the veins are depreciated. The coal is generally very good, but the veins are smaller, and, consequently, less productive, in the central and western parts of the region. But in the southern part, or north side of the Locust Mountain, they have the same dimensions and excellence which distinguish them on the south side of the mountain; but they depreciate in size and character to the north and west. The coal becomes softer, particularly at the western extremity, or at Trevorton, where it assumes the character of a semi-anthracite. But though the seams are less in size, they are more in number, and have the appearance of having, in some instances, been divided. This is manifestly the case with the Mammoth, which is here known as the "Twin veins." There are also several indefinite, irregular, and unreliable veins in the conglomerate below the position of A; but to these we shall pay no attention, because they are merely local deposits and have no uniform existence or consistent place in the anthracite coal measures.

We are guided more by the developments and investigations of William H. Marshall, Esq., of Shamokin, and the practical experience of the older operators, in regard to the formation of this region, than by the geology of the field by Professor Rogers. But we may here state a fact which our readers may notice. We have followed no predecessor, and copied no stereotyped opinions or theories, but have, with much labor and perseverance, collected the data we have used from hundreds of practical sources, and have endeavored to evoke system and uniformity out of the heretofore confused and diversified character given to our coal-fields. We have thoroughly identified the seams, and shown a consistent uniformity throughout the anthracite regions. Yet we must confess an uncertainty and doubt in our classification within this region. The veins are less characteristic, and present few of the identifying types we meet in other regions; but this peculiarity is perhaps more local than general, and our lack of personal familiarity with the entire region may prevent a proper appreciation. As formerly stated, we have every reason to believe the coal-seams are consistent throughout the anthracite regions, and occupy, respectively, a uniform place in the coal measures. We have, therefore, taken the Mammoth or Twin veins as a base, and applied our nomenclature here as elsewhere, omitting the seams found in the conglomerate below A, since those veins are not consistent even here, and are not found generally in any other portion of the anthracite fields. Rogers makes E, or the Twins, his eighth and ninth veins, independent of a small, irregular seam found far down in the conglomerate, which he names "zero." We have not represented the two lower seams as found at Trevorton or Zerbe's Gap, and have only traced the third and fourth in the conglomerate below A.

To account for this increase of the seams, we can only give the theory

of division, or a splitting of the beds, as in the case of the Twins. The lower coal-beds are invariably divided by heavy slates, as in the case of the Buck Mountain; and the probability is that the slates have increased in thickness and widely separated the seams which are counted as a unit in other fields or regions.

FIG. 62

Figure 62 is a vertical section obtained from developments made at the Burnside colliery, two miles south of Shamokin, and from data furnished by William H. Marshall, of Shamokin. It appears to be a general type of the central basins, though not a fair representation of the southern basins, or that portion of the field in the vicinity of Locust Mountain, which partakes of the character of the Mahanoy region; nor does it present a correct representation of the western end of the field, in the vicinity of Trevorton, where the veins are rather thicker than those shown in this section.

FIG. 63.

We think, however, it is about as fair a type of the central portions of the Shamokin region as can be offered; but the beds are better and more productive in the Mount Carmel basins, including the Locust Ridge anticlinal, than those portrayed in figure 62. The Mammoth, westwardly, maintains its twin form, but in the eastern and southern portions it is consistent with its general size and dimensions, or divisions, and is very productive in coal, and excellent in the quality of the same. At or near Trevorton the Twins consist of two large veins, Nos. VIII. and IX. of Rogers, each from 16 to 20 feet in thickness, and divided by a considerable body of slate and rock, of indefinite thickness, but enough to entitle the Twins here to be ranked as separate and distinct beds.

TWIN VEINS (E) NEAR SHAMOKIN.

VERTICAL SECTION NEAR SHAMOKIN.

Farther east they depreciate in size, but come closer together. The Twins in the vicinity of Shamokin range from 7 to 9 feet thick each, and are divided by rock and slate which varies from 10 to 30 feet in thickness. The accompanying illustration, figure 63, will convey a

general impression of the character and form of the Twins, or Mammoth, in this locality. It is not singular to this region, as we find the same splitting process in effect at Mount Laffee, in the Schuylkill region, and at several other points. But it is not the normal condition of the Mammoth, and may be considered a serious imperfection wherever found.

There is considerable variation in the relative sizes of the Twins; but generally the lower portion of the vein is the largest, and varies from 8 to 20 feet in thickness. The upper section is also variable, and ranges from 6 to 16 feet in thickness.

We give a concise description of the order and size of the veins as developed in the Trevorton district,—adapting the nomenclature of that region with that used in figure 62, with which it may be compared for a proper conception.

Relative Sizes and Position of the Coal-Beds at Trevorton.—South Dips.

Coal 0. "Zero"—0 to 9 feet in thickness, unreliable and unproductive; slaty and soft.

" 1. West side of gap 9 feet thick, red-ash, impure, unreliable, and frequently "pinched out."

" 2. West side of gap *pinched out;* east side 8 feet thick; three-fourths dirt and slate.

" 3. West side of gap 9 feet good coal; on east side only 12 inches poor coal.

" 4. West side not found; east side 15 inches. This corresponds with A in our section, and is the first regular vein near the top of the conglomerate.

" 5. West side 15 feet thick, divided by slates, shelly and impure; east side comparatively good and productive. This is our B, or the Buck Mountain seam, and is characteristic of that bed generally.

" 6. This is a small seam, only 15 inches in thickness, and is found on both sides of the gap,—perhaps C.

" 7. Is also small, but good, containing 3 feet of coal, and is found on both sides of gap.

" 8. Is a large, fine bed, 15 feet thick on each side of gap.

" 9. Is also a large seam of good coal, 15 feet thick on each side of gap. These beds, 8 and 9, are the "Twins," or Mammoth, represented by E in our sections. Three-quarters of a mile west of Trevorton, near the extremity of the coal-field, they unite and form a large bed 30 feet in thickness. They also unite on the south of the field, in the vicinity of Mahanoy or Locust Mountain, but form two smaller veins, as before noticed, in the vicinity of Shamokin.

" 10. On the west side is 2½ feet thick, and the same on the east side. This corresponds with the Holmes, or F, and is the upper vein in the Trevorton district.

Continuation of the beds in the Shamokin district above F.

Coal 11. The Primrose, or G, is found near Shamokin, 150 feet above the Twins, and is generally characteristic, or enough so to identify its peculiarities as those pertaining to G wherever found. It ranges from 7 to 10 feet in thickness.

" 12. Is H, or the Big Orchard, lying above the Primrose, and is here in its full development.

" 13. Is less certain as to its identity. It lies too far above the Primrose—200 feet—to be the Little Orchard, and is, moreover, too large for that vein: yet it is not far enough removed to be the North Diamond, or J, though its size and character would denote its identity with the last-named seam. This seems to be the highest workable seam or vein in this portion of the region; but it is supposed that K exists in the basins between the Locust Mountain and Red Ridge.

BASINS, OR SYNCLINAL TROUGHS.

Figure 61 illustrates in a general way the undulations of the Shamokin coal-field or region, but does not represent the full number of basins, of which there are not less than 14 or 15 narrow synclinal and parallel troughs, or small subordinate basins. There are three prominent anticlinals within the region: namely, the Mine or Green Ridge, counting from south to north, the "Red Ridge," and the "Coal Run Ridge." These anticlinals start out from the Big or Shamokin Mountain on the northeast, and run parallel through the region to the Mahanoy or Locust Mountain on the southwest, dying down at a few points through the centre of the region, but holding their course consistently nevertheless.

Within these three principal anticlinals are ten other smaller anticlinals, or saddles, of less vertical and horizontal dimensions. These anticlinals, or saddles and ridges, divide the region into a corresponding number of basins, or synclinals: of these there are four principal ones, bounded on the south by the Locust or Mahanoy Mountain, and on the north by the Big or Shamokin Mountain, and traversed by the anticlinal ridges before mentioned. These three principal basins are again divided by numerous subordinate saddles into a corresponding number of subordinate basins, which exist as long, narrow, parallel troughs. This frequent form of basin or saddle—synclinal and anticlinal—brings the seams in constantly recurring waves or undulations to the surface, and presents their outcrops in oft-repeated lines of strike. The hills, or dividing ridges, being generally of considerable altitude, this form of undulation consequently presents a large amount of coal above water-level, and brings all the coal-beds within a reasonable distance from the surface. We presume none of the workable seams are over a thousand feet vertical in any portion of the Shamokin region; and the Mammoth is accessible generally with a mode-

rate depth of shafting, say from 200 to 500 feet. But slopes are, or will be, generally in use in this region; though to the present time most of the mining is done above water-level by drifts and tunnels.

AVENUES TO MARKET.—COAL-TRANSPORTING RAILROADS.

Four lines of coal-transporting railroads now exist from the Shamokin region to the several markets.

The first and oldest is the Shamokin Valley & Pottsville Railroad, which extends from Mount Carmel to Sunbury, a distance of 27 miles. This road connects with the Northern Central, and over it has an avenue by rail to Baltimore and all intermediate points. It also connects with the Susquehanna Canal at Sunbury, which gives Shamokin connection by water with the same points. This railroad also connects with the Sunbury & Erie, and over it has direct communication with the Great Lakes and the Northwestern cities, which now consume considerable quantities of anthracite coal.

A second line of rail connects the Shamokin Valley & Pottsville with the Mine Hill & Schuylkill Haven Railroad, *via* Locust Gap and Big Run. This, however, is a continuation of the Mine Hill road, which extends from Schuylkill Haven to Locust Gap, *via* Coalcastle, Planes, and Big Run, a distance of 28 miles. This line furnishes a direct communication with Philadelphia for the coal-trade of Shamokin.

A third line extends from Mount Carmel, *via* Centreville, Shenandoah, and the Quakeake Valley, to the Beaver Meadow Railroad, a short distance below Weatherly. This line—the Lehigh & Mahanoy Railroad—is 40 miles in length, and opens communication with the New York markets, *via* the Lehigh Valley and New Jersey Central Railroads. A fourth line leads from the Trevorton mines to Port Trevorton, on the Susquehanna, a distance of 13½ miles.

SHAMOKIN COAL-TRADE FOR 1864.

John Haas & Co	54,133
Joseph Bird	52,739
Shamokin Coal Company	39,933
John B. Douty, agent	33,578
Hough & Hersh	31,122
Burnside Coal & Iron Co	22,794
Schall & Donahoe	25,105
Montelius & Co	21,283
S. Bittenbender & Sons	12,727
Hoover & Co	7,058
S. & B. Valley Coal Company	6,342
J. H. Dewees & Bro	1,916
J. B. Douty & Co	1,352
Lomison & Co.	1,101
Coal Ridge Imp. Co	766
May, Patterson & Bro	682
J. R. Boughner	363
S. Tiley	160
Pennington, Douty & Co	70
Kelley	8
	333,478

Of this amount 210,360 tons passed over the Mine Hill & Schuylkill Haven road to the Philadelphia markets, and the balance, 123,118 tons, passed over the Shamokin Valley & Pottsville road to Sunbury and the Southern and Northwestern markets.

In addition to the above, we must add the products of the Trevorton Coal & Railroad Company, which sent to market during 1864	56,301 tons.
Amount by other roads	333.478 "
Total from the Shamokin region	389,779 "

The Lehigh & Mahanoy Railroad was not completed for last year's trade; and it will be as much as the company can do to get it in operation in 1865. When completed, however, it will open an available avenue to the New York markets, with some advantage over the Lower Wyoming mines, and on nearly equal terms with the Upper Lehigh basins.

CHAPTER XI.

THE FIRST, OR SOUTHERN COAL-FIELD.

Its Form and Extent—Mine Hill Basin—Area of Coal-Field—Topography—Sharp Mountain—Jugular—Geology—Map and Sections—The Conglomerate—Thickness and Extent—Coal Measures—Lehigh District—Room Run Mines—Summit Mines—Great Open Quarry—Modes of Mining—Tunnels—Identity of Coal-Beds—Sections—Tamaqua District—Folded Strata—Repetition of the Coal-Beds—Sizes of the Seams—Transverse Section—Vertical Section—Sizes of the Coal-Beds—Section at Greenwood.

THE first of the anthracite coal-fields lies on the south of the anthracite regions, and extends in an east-and-west direction from the Lehigh as its eastern extremity to a point near the Susquehanna as its western terminus. It is a long and narrow basin, or series of parallel basins, consisting of a number of long, slender, synclinal troughs and sharp, narrow, anticlinal ridges, which traverse the coal-field in échélon from south to north by the right flank. This general strike of the anticlinals is consistent throughout the anthracite regions; and, while the coal-fields themselves lie in the same form on the map, with a general direction from east to west, the axes of formation all point northeast and southwest.

The extreme length of the South coal-field is about 73 miles, with a mean breadth of two miles and a maximum of five miles. It commences on the Lehigh in a sharp, narrow point, and gradually widens towards its centre, which is about the location of Minersville. From this point it depreciates in size towards Tremont, where it is about three miles wide, and from thence again increases to the point of division, five miles west of Tremont, where the field is separated and forms two prongs, or long, slender extensions. The south fork preserves the general western direction, and extends about 27 miles from the point of division, in the vicinity of Lorberry Creek, to a point near Dauphin on the Susquehanna. The north fork projects in a northwestern direction, on a line with the axes of formation, or the anticlinals of the field generally. It is about 17 miles in length, from the vicinity of Rausch Creek to a point three miles west of Bear Gap, in Lykens Valley.

A distinct body of coal, known as the Mine Hill basin, but included in this field, lies along its northern edge in a central position: it is 14 miles long, with a maximum breadth of about half a mile.

The entire area of the coal-field is estimated at 146 square miles, and

has been divided by P. W. Sheafer, one of our prominent geologists and mining engineers, into the following districts and areas:—

	Sq.	Acres.
1. Lehigh coal-district, east of Tamaqua	16	10,240
2. Tamaqua to Pottsville	36	23,040
3. From Pottsville to forks of basin	55	35,200
4. North fork, Lykens Valley prong	16	10,240
5. South fork, Dauphin prong	15	9,600
6. Mine Hill basin	8	5,120
	146	93,440

Compared with the Middle coal-field, the Southern field is one-third greater in extent; but with the Northern coal-field, it is one-fourth less. The three principal coal-fields form an aggregate area of 435 square miles: consequently, this field constitutes about one-third of the area. The Lehigh basins, which are a detached group, have an aggregate area of 35 square miles; which swells the entire area of the anthracite regions to 470 square miles.

TOPOGRAPHY OF THE FIELD.

The Southern coal-field is bounded and set by the same frame or character of mountain-ranges as those which distinguish the other anthracite fields. The range on the south is continuous from one end of the coal-field to the other, and is known as the Sharp Mountain. It is a steep, sharp, monoclinal mountain, with a crest of coarse massive conglomerate, and a base on the south of soft red shale. The outcrops of this range are all south, and the dips to the north, underlying the first basins of the coal-field. At the eastern extremity of the field the Sharp Mountain unites with the Locust Mountain, and is known as the Mauch Chunk Mountain. It terminates in an abrupt point, almost overhanging the Lehigh River, and towering over one thousand feet above it. This terminal knob or point is known as Mount Pisgah, and is crowned by the engines of the Lehigh Coal & Navigation Company, for the elevation of their coal-cars up the Mount Pisgah planes to the head of the back track, which is a gravity-line, to the mines, and which we will describe under the proper head, appropriate to our mining establishments, in the Appendix.

From the Lehigh to a point about 20 miles west, the north range is known as the Locust Mountain; but whether this is intended as a continuation of the Locust Mountain of the Middle coal-field is not clear. There is no geological or topographical connection between the two; but such a nomenclature would be no more arbitrary than the misnomers which distinguish the topography of Mahanoy and Shamokin.

At the point named, the Locust Mountain—which, like the Sharp Moun-

tain, has a monoclinal axis, but with a northern outcrop and a southern dip—unites with the Broad Mountain. This mountain, as the map indicates, is a broad, undulating plateau of conglomerate, lying between the

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central portions of the Southern field and the Mahanoy division of the Middle field: its maximum breadth is about six miles, and its greatest length twenty miles.

It contains several small, independent basins of coal along its summit, which we shall describe separately, as they have no connection with the other coal-fields.

Along the southern foot of the Broad Mountain lies the Mine Hill basin, which is simply separated from the main coal-field by the sharp and narrow anticlinal ridge of the Mine Hill, which at each extremity enters the Broad Mountain, and of which it seems a part, separated only by the Mine Hill basin. This small basin lies deep in its central portions, but its extremities are elevated to the surface. Like an Indian pirogue, it is long and narrow, deep in the middle, but pointed, sharp, and elevated at the ends. There is, however, a second subordinate basin within the main one, lying on the north, which, like a second canoe, smaller, sharper, and more narrow than the first, lies alongside. This is called the Jugular synclinal, and is divided from the first by the Jugular anticlinal: at each extremity of the smaller basin this anticlinal distinctly separates the two basins, but in its centre the coal-veins overlap the saddle and connect the strata on the axis.

This northern basin is peculiarly sharp, deep, and narrow,—its strata having a uniform dip in its centre to the south. The should-be north dips are inverted, and really underlie the south dips of the main basin. This peculiarity was at first a source of much speculation and misconception by our mining engineers, since the coals of the entire basin were mistaken for underlying veins; and much time and money has been spent in vain efforts to discover them elsewhere.

The Mammoth is so doubled and brought in connection in this basin that it has been taken for one vein of enormous thickness, and called the "Jugular;" while the four underlying veins are also repeated: so that, in appearance, there would seem to be twelve or thirteen veins underlying the Mammoth in the Mine Hill basin. Figure 64 represents the two

Fig. 64.

WOLF CREEK, MINE HILL BASINS.

basins at the eastern extremity of the formation, or where the Mammoth is unearthed, in the vicinity of Mill Creek Gap, above St. Clair.

The Mine Hill formation is parted near its western end by the Peaked

Mountain, and divided into two miniature prongs or forks, in imitation of the western division of the main coal-field. Here the main basin forms two distinct synclinals, divided by the anticlinal of Pickett, or Peaked, Mountain.

We have, perhaps, diverted attention from the bounding mountain-ranges of this field by stopping to notice the Mine Hill basin; but it will be remembered that the Locust Mountain forms the north boundary about 20 miles along the eastern end, and enters the Broad Mountain. This range or mountain-plateau, then, forms the north marginal line of the field for a distance of about 20 miles to a point near the Falls of Swatara. From or near this vicinity Thick Mountain forms the north boundary past Tremont and beyond the main forks of the field to some indefinite point, —perhaps Klinger's Gap,—and from thence to the western extremity it is known as Short Mountain. Thus the bounding mountain-range to the north is locally named and known by the primitive nomenclature, which applied the cognomens from local features, without regard to geology or topography. The "Mine Hill" would be an appropriate name for the entire range, since it would be nearly continuous and would really form a bounding line from east to west, leaving the Mine Hill basin outside and independent of the main field,—as it is, with the exception, perhaps, of an uncertain connection near Swatara; but even here it is doubtful whether the underlying veins connect.

A section of the field in the vicinity of Swatara will be found farther on, from data furnished by Col. D. P. Brown, who is practically familiar with that portion of the coal-field.

The south boundary of the north fork is known as Big Lick Mountain: it unites at the point of division with the Fourth or Stony Mountain, which forms the north boundary of the south or Dauphin fork, and at the western extremity with the Short Mountain, which is the terminal knob of the north or Lykens Valley fork. The Big Lick Mountain, above noticed as the north boundary of the south fork, unites at the western extremity of the Dauphin prong with the Sharp, or, as it is locally called, the Third, Mountain.

All these bounding mountains, with the exception of the Broad Mountain, are monoclinal ridges, with crests of massive conglomerate and outward bases of red shale. Those on the south have north dips, and those on the north south dips, forming an interior undulating basin from crest to crest of those marginal mountains. A glance at the map will show the blue outlines of those conglomerate monoclinals surrounding the basin, with the plateau of the Broad Mountain stretching from the First to the Middle coal-field. With this exception, the blue border is set in a wide frame of red shale, which not only partially surrounds the first coal-field, but completely envelops both the First and Second, or Southern and Middle, coal-

fields. The dark tints of the coal lie in long, narrow strips in the centre of those borders of blue and red, and exist in nature as portrayed in the map.

The interior of the coal-field is peculiar. Its topography and botany, as well as its geology, differ widely from the surrounding border. The interior ridges, with the exception of the Mine Hill,—which is of the same formation and character as the surrounding mountains,—are undulating and diversified. They conform to the water-courses more than to the anticlinals of the coal measures, and, consequently, roll in all directions, as frequently at right angles with the mountain-ranges as parallel with them. The interior sides of the marginal mountains are generally lapped with the coal measures half-way to their summits; but above the coal is exposed the white and massive conglomerate.

The softer shales, slates, and sandstones of the red-ash coal measures—the upper series of Rogers—form a warm, dry, and friable soil, which produces and supports a vegetation peculiar to itself or to such formations generally in this latitude, and not only to this, but to all the anthracite and bituminous fields. We notice, however, that the soils in the vicinity of the white-ash veins are colder and more silicious, and produce quite a different vegetation; while the upper or red-ash coal measures produce the chestnut-oak, chestnut, dogwood, laurustinus, and such dry, warm-soil trees and shrubs: the lower or white-ash coal measures and the conglomerates support the resinous pines, swamp-oaks, hemlock, bay-laurel, ferns, &c., or such vegetation as grows in flinty, silicious soils or cold, low grounds.

The red shales lying below the conglomerates also support a warm growth of vegetation, similar to that produced by the upper coal-measures; but neither produces nor supports, to any extent, the botanical productions of a rich or luxuriant soil. The walnut, poplar, hickory, cherry, locust, elm, &c. do not exist within the anthracite coal-fields or in their vicinity.

GEOLOGY AND INTERIOR FORMATION OF THE FIELD.

Included in the Carboniferous strata we find the Vespertine sandstone, the proto- or subcarboniferous, and the Umbral red shales, both overlying the Ponent, or old red sandstone of the English, and underlying the conglomerate.

The vertical section on the left side of the accompanying map of the anthracite coal-fields is designed to illustrate the formation in the vicinity of Pottsville, from the Vespertine to the top of the coal measures. It will be noticed that the Vespertine is colored in the sections as in the map, while the Umbral red shale is the same in each; the conglomerate blue, and the coal a black tint. Thus the map and sections illustrate at a

glance the geology of the coal formations, and will convey a better impression than words, or any written description, of the character and general formation of our coal-basins and their subordinate strata.

We have given four geological sections on the map:—first, a vertical section of the anthracite formations near Pottsville; second, a vertical section of the Western or bituminous formations, which may be accepted as a general type of the great Alleghany coal-field, but not the more western coal-fields. We will give a general section of the more western fields in connection with the Great Central coal-field of Illinois and Indiana.

The third section on the map is a transverse section from the Lehigh Summit mines, in the eastern end of the Southern coal-field, across the Lehigh basins, to the lower or western end of the Wyoming or Northern coal-field. The fourth is a transverse section from Pottsville, across the middle of the Southern coal-field, the New Boston or Broad Mountain basins and the Mahanoy region of the Middle coal-field, to the vicinity of Shenandoah City. From thence the continuation of the section is from Locust Gap across the Shamokin region of the Middle coal-field to Shamokin. The principal undulations are only given in the latter region.

The *scale* and the colors of the different formations will be sufficient to explain them, without further description.

THE GREAT CONGLOMERATE.

This peculiar rock seems to be the base-rock or floor of all the true coal formations, or those of the great Carboniferous era, throughout the world, wherever such coal is found. We do not find any great, reliable, or extensive coal-field in any other condition. An exception can scarcely be made to the Great Australian coal-field, or the coals of the subcarboniferous period in England, since neither of those coal formations is practically developed or definitely assigned to a prominent position; while the first is still in a doubtful status as to its relative age or position.

In the vicinity of Pottsville the conglomerate is over 1000 feet thick, a vast heterogeneous mass of firmly-cemented quartzose nodules, from the size of a pin to that of a hen's egg, diversified by intervening strata of coarse sandstones, shales, and sometimes thin veins of coal. It is an extremely persistent deposit, and is found everywhere below the coal, throughout the bituminous as well as the anthracite fields.

At the eastern extremity of the Southern field, near Mauch Chunk, the conglomerate is 950 feet thick; at Nesquehoning, a few miles farther west, and on the opposite side of the field, it is 792 feet thick; at Tamaqua it is 803 feet; at Pottsville, 1030 feet; at Lorberry Gap, 675 feet; at Yellow Springs, 660 feet; and at Bear Gap, Wiconisco, 460 feet. But at the latter

place it is found doubled between the north and south basins, as shown by figure 93.

In the Lehigh detached basins it is generally about 700 feet; at Mahanoy, near Ashland, 800 feet; and at Shamokin, 630 feet. At Solomon's Gap, in the Wyoming region, it is 170 feet thick, and at Nanticoke, 60 feet; but here the underlying coarse sandstones sometimes increase it to nearly double those dimensions.

In the Broad Top coal-region, which lies about 30 miles east of the margin of the Great Alleghany coal-field, and a little west of the Wyoming formation, the conglomerates appear to be 100 feet thick, and, inclusive of the coarse sandstones between the coal and the red shales, 250 feet.

In Sullivan county is found the most eastern and northern coal-basin of the great Western bituminous formations; and here the conglomerate is a coarse, massive rock about 30 feet thick; while the sandstones between the conglomerate and the red shales are frequently from 300 to 500 feet thick, containing one or two seams of imperfect limestone.

The conglomerate proper continues to depreciate to the west, and frequently consists of a thin plate of fine-grained sandstone, only ten (10) feet thick, but so set with quartzose pebbles as to be unmistakable in character. Yet accompanying this conglomerate plate are frequently large and massive strata of coarse sandstone, which belong properly to the millstone grit. In the Great Central coal-field in Illinois this millstone grit, which is synonymous with our conglomerate, is 300 feet thick, according to Prof. Wilber, of Illinois.

COAL MEASURES.

NESQUEHONING OR RHUME RUN MINES.

As this will embrace a general description of the coal-field, its undulations, basins, saddles, and axes of formation, with the coal-seams and other details, we will commence at the Lehigh extremity, and describe the field in districts, with sections to illustrate its general features.

The Rhume—or, as it is sometimes written, the Room—Run, or Nesquehoning mines, are the most eastern of any importance. The coal measures exist here almost on their ends, as our miners would say; that is, they are nearly vertical, and are formed into two deep and narrow basins, which rise rapidly in an eastern direction. The south dips of the north basin are from 45° to 50°; while the north dips of the same basin are vertical. The axis, or saddle, between the basins is sharp and narrow, and the south dips of the south basin are from 50° to 60°; while the north dips, as proved at "Hackleburney," are inverted; that is, they dip south at their outcrops and change in their descent to the north. The veins cut here in the old tunnels were counted twice, as they were cut through both

south and north dips in the same basin before it was known that a basin existed at the point: consequently, they were named and numbered respectively as separate beds.

There is some difficulty in recognizing the identity of the veins in this locality, from the great change in their sizes and character; and, though a number of tunnels are driven from this point beyond the old mines at the summit, there seems to be no conformity or general sameness in any of the tunnels, since the veins range in size and character to extremes. The *Big vein* is undoubtedly the Mammoth; but, as far as proved, the Buck Mountain does not appear in its usual condition, though the other veins are frequently larger than usual: yet these conditions are not generally as favorable as they are when in their average sizes.

The following table will present the names and identity of the beds as near as it is possible to do under present development:—

No.	Vein.	*Thickness.	Workable Coal.	Remarks.
1	Rotten vein	7 feet.	5½ feet.	Shelly coal.
2	Twin coals	3 “	2 “	Not reliable.
3	28-feet vein	22 “	9 “	Buck Mountain?
4	Double vein	9 “	9 “	Changeable.
5	19-feet coal	29 “	17 “ E	Mammoth?
6	39 “ “	26 “	15 “	Mammoth?
7	12 “ “	16 “	12 “	Primrose?
8	Pencil vein	14 “	12 “	Identical with 7.
9	Brown's vein	14 “	... E	“ “ 6.
10	Vertical	18 “	16 “	“ “ 5.
11	6-feet vein	6 “	....	“ “ 4.
12	4-feet vein	4 “	....	“ “ 4.
13	50-feet vein, north dip	25 “	....	“ “ 3.
14	50-feet vein, south dip	31 “	....	“ “ 3.
15	3-feet vein	4 “	....	“ “ 4.
16	10-feet vein	18 “	16 “ E	“ “ 5.
17	26 “ “	26 “	20 “	“ “ 6.
18	14 “ “	14 “	....	“ “ 7.
19	11 “ “	11 “	....	“ “ 7.

There seems to be some doubt as to which is the Mammoth at Nesquehoning, whether it is No. 3 or Nos. 5 and 6. No. 3 is in the proper position of the Buck Mountain vein, and Nos. 5 and 6 are where the Mammoth ought to be, but are here divided. If we accept Nos. 5 and 6 as the Mammoth, we can identify the remaining veins with those existing in other localities; but if No. 3 is the Mammoth, we cannot. Some of the small seams cut in those tunnels have not been recognized; and it is scarcely possible to trace the veins from their north to their south dips, owing to these omissions, since in this locality the veins vary to extremes from their maximum to their minimum sizes, in short distances.

It will be observed in the foregoing table that only seven veins exist in this section of the field; and it is not at all probable that any of them are above the Primrose, or G; and this, which is No. 7, or the 12-feet vein, appears to be the same as No. 8, or the Pencil vein,—one being the south and the other the north dip. Nos. 5 and 6 would thus appear to be identical with Nos. 9 and 10, and these would appear to be the Mammoth divided, as it frequently is in many portions of the coal-field.

Nos. 3, 13, and 14 would thus be the Buck Mountain on different dips. But we must confess that this theory is based on what ought to be the condition of the veins, more than on the developments; and yet it is both possible and probable, notwithstanding appearances to the contrary. The following section of the so-called Mammoth at the Nesquehoning mines does not come up to our ideas of its proper proportions, and particularly when we know that its overlying veins are of equal or greater dimensions.

FIG. 65.

MAMMOTH? AT NESQUEHONING.

We may remark in this connection that our data are chiefly derived, in this instance, from Rogers's late report, or Geology of Pennsylvania, which, unfortunately, presents a "tangled web" in almost every attempt to justify the coal strata. We must add, also, that the Lehigh miners have made no attempt to classify or identify their veins; and, though we were kindly furnished all the information available, it has been impossible to bring order out of the confusion that here exists. The question, however, is simply this: Is the first large vein above the conglomerate the Mammoth, or the Buck Mountain? If the latter, then Nos. 5 and 6 of the foregoing table are the Mammoth, and the veins fall into order and are in place, as shown by figure 66, in which we have given all the veins, large and small, and have named them, as all our sections are named, *a*, *b*, *c*, *d*, *ee*, *f*. If the contrary is correct, then *b* would be *e*, and *ee* would be *g*, *h*, or the Primrose and Orchard,—which is impossible, since those veins have never been found as large as these would make them. Again, the lower veins here are *red-ash*, while the upper ones are white-ash; and this should be sufficient to confirm us in our conclusions.

FIG. 66.

THE NESQUEHONING BASINS.

LEHIGH SUMMIT MINES.

PANTHER CREEK VALLEY.

The waters of the former mines, or Rhume Run, at Nesquehoning, running east, fall into the Lehigh River; while the waters of Panther Creek Valley, running west, unite with the Little Schuylkill at Tamaqua. The basin or field widens in this direction, and the veins which are vertical at Nesquehoning are here changed to moderate angles, and, consequently, to more favorable conditions both in regard to the character of the veins and the quality of the coal. At Nesquehoning the veins are not reliable. Their present vertical position was not their original or normal condition, which must have been at a comparatively low angle. The violence which threw them into vertical positions crushed and destroyed their uniformity and seriously injured the workable qualities of both veins and coal. There is only one vein worked at present at the Rhume Run mines, a section of which is given in figure 65.

At the Summit and Panther Creek mines the Lehigh Company have confined their operations exclusively to the Big vein. Three modes of working have been pursued. First, the great bed at the Summit was quarried successfully, as ordinary rocks are quarried, in an open quarry. This they were enabled to do by the immense thickness of the bed and its proximity to the surface. But little cover or earth rested over it, and this was easily removed, leaving a mass of coal over 50 feet thick fully exposed. Figure 67 will explain this peculiar formation.

Fig. 67.

PANTHER CREEK AND SUMMIT HILL TRAVERSE.

The folded black stratum on the right of the section, resting against or on the sharp mountain-range, is the location of the celebrated Lehigh quarry. The upper portion of this coal was worked in the daylight, by uncovering it or removing the thin strata of slate, shale, and earth which covered it. The deeper portions have been mined by slope in the ordinary manner. It will be observed that the bed is frequently doubled, forming several sharp axes. In these cases it is of enormous thickness, or double its real size. Should a tunnel be driven across the folds, the vein would be cut five times in succession, and yet have the appearance of being but one bed of coal. The operations of the forces which formed our deep and

inverted basins are here fully demonstrated. It is evident that no lifting force exercised by the laws of nature would or could produce the effects here demonstrated. That a *depression* of the basins of Nesquehoning aided to form their present deep and steep condition, needs no further proof than is offered in figure 66; and that *contraction* completed the work, by crushing the strata together and inverting the measures, is equally evident. These forces are irresistible.

In figure 67 we see another remarkable evidence of contraction. The general form of the basin on the summit is evidently very near its original condition, with the exception of the peculiar folding exhibited along its centre. It was once a uniform basin, of moderate depth and gentle undulation; but since the formation of its coal, or during the Carboniferous era, the Panther basin became depressed, and perhaps the summit became slightly elevated by the forces which contracted the measures or crushed them into their present folded or corrugated shape. Our section presents this formation at its minimum angles. The dip along the Sharp Mountain range is frequently greater. But this upper basin is limited in extent, and, though the coal is of enormous thickness locally, it is confined to a space of less than a square mile.

FIG. 68.

SECTION OF MAMMOTH, FROM THE OPEN QUARRY AT THE SUMMIT MINES, LEHIGH.

The large vein here developed is undoubtedly the Mammoth, however it may connect with the Nesquehoning veins. The accompanying section illustrates its size and character, as worked in the open quarry. The style of the engraving differs from those we have furnished as originals; but it is neverthelesss correct, and consistent with the original section furnished us by Mr. Patterson, the General Mining Superintendent of the company. It will be noticed in another part of this work that we have purchased some of the elegant illustrations from the publications of the Messrs. Harper. This is one of them.

Figure 68 represents a perpendicular view of the stratification of the Mammoth, in the celebrated Open Quarry at the old Lehigh Summit mines. It ranged from 50 to 70 feet in thickness, and was covered with from 6 to 20 feet of earth and slates. But the thickness of the covering increased rapidly from the crest of the anticlinals or saddle to the synclinals or basin; and it was found more economical, eventually, to excavate the coal by the ordinary processes of mining, than by the old or original mode of quarrying.

The Summit basin is now worked by slopes. Slope No. 2, in "Spur Basin," on the Summit, dips south at an angle of 16°, and is 1290 feet long. Slope No. 4, east of Summit Hill, dips north at an angle of 69°, and is 406 feet long. These are the only mines now worked in the Summit basin. Slope No. 1 is abandoned, the coal being on fire.

Slope No. 3 is in the Panther Creek Valley, and starts within tunnel No. 6, on the Big vein. It is on the south dip, at an angle of 44°, and is 306 feet long.

Slope No. 5 is in tunnel No. 8. Its length is 300 feet on the south dip, at an angle of 44°. In addition to those four slopes, there are two tunnels in operation, and a fifth slope, in the vicinity of Tamaqua, independent of the Nesquehoning mines, and the "old tunnel" mines near Mauch Chunk.

The following notes will convey some idea of the irregularity of the veins. They are taken from parallel tunnels less than a mile apart. Some ten or twelve extensive tunnels have been driven by the Lehigh Company to develop their property. The veins traverse the valley parallel to its course from east to west, outcropping high up the mountain-sides, and covered by a considerable thickness of overlying strata in their dips to the centre of the basin or valley; while the conformation or slopes of the mountain-sides are much less than the angle of the coal: consequently, the coal can only be reached, practically, by long tunnels.

Horizontal Section of Tunnel No. 7, running north, and on north side of Panther Creek Valley.

	Ft.		Ft.
Measures, slate, rock, &c.	60	Coal, south dip 38°	1
Coal, Mammoth, on anticlinal axis, dip 50° south, 73° north	64	Measures	175
Measures	129	Coal, south dip 46°	24
Coal, Primrose? dip 69° N.	15	Measures	53
Measures	81	Coal, south dip 39°	9
Coal, north dip 76°, Holmes?	3	Measures	274
Measures, perpendicular in centre	220	Coal, south dip	1
Coal, south dip 42°; Holmes?	5	Measures	54
Measures	109	Mammoth?* south dip 45°	50
Coal, Primrose? south dip 44°	23		
Measures	177		

* Air-hole to surface from this vein 486 feet long, being about the length of breast.

Horizontal Section of Tunnel No. 6, running north, and on north side of Panther Creek Valley.

	Ft.		Ft.
Measures, slate, rock, &c.	180	Measures, south dip	111
Coal, south dip 33°	5	Coal, south dip 39°	9
Measures, south dip	117	Measures, south dip	243
Coal, south dip 32°	10	Coal, south dip 45°	27

Horizontal Section of Tunnel No. 6.—(Continued.)

	Ft.
Measures, south dip 45°	9
Coal, south dip 45°	2
Measures	239
Coal, south dip	1
Measures	88½
Coal	1
Measures	3
Coal, south dip 45° Mammoth?	66

None of the Lehigh tunnels appear to have been driven beyond the "Big vein;" therefore the measures below it are not developed, and the Buck Mountain, or B, is in doubt.

Horizontal Section of Tunnel No. 5, running south, and on south side of Panther Creek Valley.

	Ft.
Measures, slate, rock, &c	393
Coal, north dip 71°	6½
Measures, north dip	126
Coal, red-ash, north dip 71° (G?).	12
Measures	224
Coal, north dip 71°	1
Measures	85
Mammoth, north dip 71° (E?)	50

NOTE.—Tunnel No. 5 presents the proper order of stratification, as found in all regular portions of the coal-fields, E being the Mammoth, and G the Primrose. But the adjoining tunnel, No. 2, presents no identical feature.

Horizontal Section of Tunnel No. 2, running south, and on south side of Panther Creek Valley.

	Ft.
Measures, slate, rock, &c	495
Coal, south dip 45°	3½
Measures	87
Coal, south dip 36°	2
Measures	27
Coal, perpendicular	3
Measures	186
Coal, perpendicular	1½
Measures	74
Coal, perpendicular	5
Measures	91½
Coal, south dip 65°	6
Measures	155
Coal, south dip 70°	6½
Measures	128
Coal, Mammoth, north dip 40°	65

These four tunnels are in the vicinity of Summit Hill, and are nearly opposite each other. That is, Nos. 5 and 2 are on the south side of Panther Creek, running south to cut the main north dips of the coal; and Nos. 6 and 7 are on the north side of Panther Creek Valley, running north to cut the main south dips of the coal. It will be noticed, by any one conversant with such matters, that no uniformity exists: in fact, there is a confusion which prevents the formation of any systematized sections that would identify the seams.

Figure 67 represents the general type of the coal formation in the vicinity of the old Lehigh mines. There are some points where the angle of the strata is more abrupt and on greater elevations than our section displays; but generally it conveys a just impression of the formations.

TAMAQUA DISTRICT.

The narrow, contracted, and vertical character of the eastern formations of the basin is fully illustrated at Tamaqua, where the folded and tilted condition of the measures exhibits all the phenomena of *depression* and *contraction*. But here the coal is less injured in quality and quantity than at Nesquehoning, and, though more abrupt and at higher angles than at the Summit, the veins are, nevertheless, equal in character and production, if not in size.

FIG. 69.

TRANSVERSE SECTION AT TAMAQUA.

The sizes of the beds, as illustrated in figure 69, are out of proportion; that is, they are too large in comparison with the same veins in other sections; but if drawn to a proper or corresponding scale with the extent of the basins, they would not be discernible. We do not pretend to project them on a corresponding scale, but simply give them to illustrate the formation, number of basins, saddles, (axis) dips, and the general conformation of the measures. In figure 69 we have the Sharp Mountain on the right hand and the Locust Mountain on the left of the view. The position of Tamaqua is near the centre, but more to the right than the left.

There are two main axes within the basin, and two subordinate rolls or folds: one of these is shown at the foot of the Sharp Mountain, to the east; the other is not represented, but lies within the west basin.

The eastern side of the basin has been more thoroughly developed than the west by shafting, and the folding of the strata, as illustrated, is demonstrated by tunnels. The two centre basins have not been penetrated, nor do we know that the third basin, or the western synclinal, has been reached; but the coals on each side of the main basin have been pretty thoroughly developed by both drift and slope.

Figure 70 represents one of those sudden rolls, or folding of the strata, so frequently met with in the Southern coal-field. The one before us does not appear to have materially affected the accompanying seams; but it is evident that this simple fold of a single vein increases the apparent number of veins in the basin by two,—or produces two more in the original Tamaqua section than really exist. The seams appear in the face of the

hill as three distinct beds, but development has proved them to be synonymous. The sketch illustrates the character of this fold simply, and is not designed as an exposition of the accompanying strata. The engraving would seem to represent the enveloping strata as slate, but such is not the intention, since rock, or sandstones and slates, alternate invariably in the vicinity of the Mammoth, and this is supposed to be that vein.

We would call attention to the angle of the north dip on the face of the Sharp Mountain at this point. It will be noticed that, though high, it is not beyond a moderate working angle, or from 60° to 70°. And here

FIG. 70.

FOLDING OF THE STRATA IN TAMAQUA SHAFT.

the coal is good, and the veins generally workable; but farther west the angles of the north dips increase, until in the vicinity of Pottsville they are inverted, and the marketable value of the coal destroyed. This seems to be a general rule: the coal is seldom good on the vertical angles, and never, or very rarely, when inverted.

We may here notice, also, the increasing number of the anticlinals within the main basin.

At Nesquehoning we find but one principal anticlinal; at the Summit we find two within the main basin in Panther Creek Valley,—independent, however, of the undulation in the Summit basin; but, as this is a local formation of small extent, it does not properly affect the prominent anticlinals. We have, however, represented but one in our section across the basin at the Summit. The second anticlinal does not appear prominently ... we reach a point farther west, and between Tamaqua and the Summit. ...amaqua we find two principal anticlinals and two subordinate ones;

while in the vicinity of Pottsville we have five principal anticlinals and several subordinate rolls or "saddles." There is always one basin or synclinal in each part of the main basin more than the number of the anticlinals, as may be noticed in any of the sections given, since the marginal mountains always form one basin, independent of the anticlinals which may divide them.

It must not be inferred from the fact of the anticlinals and synclinals—or, in mining-phrase, saddles and basins—increasing in number as we proceed west, that those anticlinals, &c. are continuous. We do not think any of those axes proceed half-way in the length of the main basin. As we before observed, all the anticlinals of the anthracite regions advance in échélon by the right flank, from south to north. They start from the Sharp Mountain, in the Southern coal-field, generally, and traverse the basin diagonally towards its northern margin. But few of those anticlinals, however, preserve their axis from margin to margin. They die out, or sink down, and another starts from their side to continue a parallel course. It is impossible to locate the course of the axis of formation throughout the coal-fields with any practical exactness at present. It can only be done by a great number of cross-sections, taken at short distances, from end to end of the coal-field; and these cannot be obtained without more time and labor than can now be profitably spent for the purpose.

It is always important that the mining engineer should establish the exact location of each axis of formation within the boundaries of every mining establishment or estate. Should we attempt to lay down the general course of the anticlinals in this work, as Prof. Rogers attempted to do, it would only be approximate, and would not be definite enough for any practical purpose. We will, however, endeavor to give such information as will materially assist the practical miner, and the engineer too, who may not be generally familiar with the region, in unravelling many of the heretofore mysterious formations of the anthracite fields. Our object is to clear away many of the doubts in regard to irregular formations, and

Fig. 71.

VERTICAL SECTION AT TAMAQUA.

to present a clear exposition, by illustration and text, of the intricate and singular contortions of the anthracite strata.

At Tamaqua we find more veins than properly belong to the white-ash series below the Mammoth; but we have before explained and represented in figure 70 the reason of this increase,—arising out of their repetition by sudden foldings.

We find, however, a consistency and order in the veins at Tamaqua which cannot be evoked out of the formations of the Lehigh. Here the veins fall into their places in order and uniformity with the other portions of the anthracite regions, where the conditions are normal or according to law. It is singular that the veins in the Lehigh district are so much at variance with all other portions of the anthracite formations. But, as we said in another place, it is possible the miners are more in error than the coal-beds.

Figure 71 is a vertical section of the Tamaqua coal measures, and may be taken as a general type of the district. We think, however, that we have been led into error by the repetitions of the beds here, and have, therefore, misapplied the names or letters. We find, since our engravings were executed, it is more than probable that C is really B, and that B, as applied, should be represented by it. This may be considered as the proper condition. Such an alteration would place D up to the 3-feet vein

FIG. 72.

MAMMOTH AT TAMAQUA.

FIG. 73.

PRIMROSE AT TAMAQUA.

under the Mammoth, which we have included with the Mammoth, or E, in order to compensate for the error of placing B in the position properly belonging to A, thus making two errors to rectify one. With this ex-

planation we hope figure 71 will be understood. We may have made other errors, but if discovered in time we will try to rectify them, as in the present case.

The Mammoth at Tamaqua is not as large as it is generally found, but we have not given its maximum dimensions. It is found in the vicinity over 50 feet thick; but we think the size given in figure 71—that is, 20 feet—about its best workable size in this district. Our data are chiefly derived from the officers of the Little Schuylkill Coal Company, and from Mr. George Brown, whose long and practical experience makes him good authority on such matters.

The Holmes (F) and the Primrose (G) are in their proper sizes and places; while the red-ash veins, H, I, and J, are also in their uniform places and sizes.

The Skidmore (D) does not, however, appear in its proper place or condition; but it is a variable vein, and we do not think it an important discrepancy, since it frequently depreciates in size.

The two following sections are on the Greenwood Coal Company's property, east of Tamaqua. The data were obtained from Mr. Robert Carter, General Superintendent.

Section of Mammoth at Greenwood.

	Feet.
Top slate	1.6½
Coal	6.0
Bone and slate	.3
Coal	5.0
Bone and slate	.3
Coal	7.0
Bone and slate	.4
Coal	6.0
Slate	.3
Coal	6.0
Slate	.4
Coal	7.0
Slate	.2
Bony coal, refused	5.0
Coal, good	7.0

Section of Measures at Greenwood.

	Feet.
Coal, H, red ash	5
Measures	100
Coal, G, Primrose	14
Measures	100
Coal, F, Holmes	2
Measures	170
Coal, E, Mammoth	50
Measures	66
Coal, D, Skidmore	8
Measures	150
Coal, C?	9
Measures	180
Coal, B, Buck Mountain	10
Measures	180
Coal, A, from 6 to	8
Conglomerate	?

It will be observed that the above vertical section through the measures at Greenwood, between the Lehigh and Tamaqua, is perfect. The veins are in full size and in their proper places. We cannot conceive how the variation can be so great, only a few miles farther to the east, at the Summit mines.

CHAPTER XII.

POTTSVILLE DISTRICT.

Pottsville District—Section across the District from the Sharp Mountain to the Broad Mountain—Basins—Subordinate Basins—First, or Pottsville, Basin—Gate Ridge Anticlinal—Second Basin—Third Basin—Fourth Basin—Fifth Basin—Sixth, or Mine Hill, Basin—Vertical Section at Pottsville—Coal-Beds—A, or Alpha—B, or the Buck Mountain—C, or Gamma—D, or the Skidmore—E, or the Mammoth and Seven-Feet—F, or the Holmes—G, or the Primrose—H, or the Orchard—I, or the Little Orchard—J, or the Daddow—K, or the Big Tracy—L, or the Little Tracy—M, or the Gate—N, or the Sandrock—Total Thickness of Coal, and of the Coal Measures—Swatara District—Lykens Valley Fork—Outcrops—Bear Valley Formation—The Dauphin Fork—Section—Red- and White-Ash Coals.

THIS portion of the Southern coal-field is prominent as its central and most developed district; and here we find all the veins known to the anthracite formations of Pennsylvania in order and uniformity consistent with other regions. Here we find, also, the deepest basins, and all the peculiarities developed in other districts. It will be interesting, therefore, and perhaps useful, to illustrate in detail the varied formations and beds of coal, and compare the facts presented and illustrated in reference to other fields and districts with those we have now before us. We shall find more uniformity and consistency than might be expected from the many peculiarities and irregularities which we find around us. But even those irregularities or contortions, if we may call them so, will be found a uniformity, subject to the same causes and governed by the same laws. We shall also find an almost invariable order of disposition in the strata and general characteristic features governing the coal-beds.

It is stated by the former State geologist, who spent much time and patient study in the investigation of our anthracite fields, that the identity of the veins was an impossibility, and that but little similarity existed between the formations or measures of the respective fields. But we find this to be a mistake, arising from misconception and the want of that practical experience and judgment necessary to distinguish between theory and fact, and to reconcile and arrange facts and data drawn from a thousand sources. Had we adopted the views and opinions of all those from whom our information was obtained, we should have made the "confusion worse confounded."

We have occasionally found much difficulty in reconciling the facts derived from different sources; but patient investigation generally brought

order out of seeming contradiction and confusion; and we have no doubt but that the "Lehigh riddle" might be easily solved by careful investigation,—which, however, we are sorry to say, time will not permit.

Figure 74 illustrates the formation and undulations of the coal measures from the Sharp Mountain, in the vicinity of Pottsville and Port Carbon, to the foot of Broad Mountain, at Repplier's Mammoth colliery, Wolf Creek, by the line of Mill Creek and St. Clair. But we shall also apply the section to the line of Norwegian Creek by Oak Hill, Mount Laffee, and Coal-castle.

The section is drawn looking east; the right-hand margin being the Sharp Mountain and the left the Broad Mountain. There are six large or prominent basins within the field and represented in this illustration; but there are perhaps as many rolls or subordinate undulations within the main ones which are not represented in the figure. First, there appears to be a slight roll on the Gate Ridge anticlinal, *h*, the first anticlinal north of the Sharp Mountain; the second developed wave, or subordinate basin, is shown within the third main basin and north of the Mill Creek anticlinal, *g;* the fourth set of undulations are found in the furnace or shaft basin, and developed in Milne's Hickory colliery. Here several minor rolls have been developed, and

TRANSVERSE SECTION FROM THE SHARP TO THE BROAD MOUNTAIN, VIA ST. CLAIR.

FIG. 74.

these undulations are also manifest in the same basin at Oak Hill, in Brown's old Primrose water-levels, and in the workings of the Primrose and Orchard veins on the west branch of the Schuylkill, near Mine Hill Gap.

John's basin, at the south foot of the Mine Hill, is small and limited in length and breadth, and can scarcely be placed among the prominent basins; but we find its counterpart at Mount Laffee, and have, therefore, laid it down as the fifth basin, instead of assigning it as a temporary roll or undulation.

The last subordinate basin we shall mention in this connection lies within the sixth or Mine Hill basin, and is known as the Jugular roll or "overthrow."

We have mentioned, thus, a few of those small and subordinate undulations before describing the principal basins, in order to prevent confusion in the statement, and enable our practical readers to follow us without noticing the future omission of those inferior basins.

THE FIRST, OR POTTSVILLE, BASIN.

1. The first and most extensive basin lies between the Sharp Mountain, *l*, and the Gate Ridge anticlinal, *h*, and underlies Pottsville and Port Carbon in this vicinity. It is nearly a mile wide from outcrop to outcrop, and is the largest basin in the anthracite fields, extending from a point east of Middleport to the end of the Dauphin Fork, a distance of not less than 50 miles. Along the entire distance it preserves its peculiar character. The north-dipping strata are always perpendicular or inverted at their outcrops, and descend, in all probability, nearly 3000 feet before a change from the perpendicular is made. This feature of the South, or Sharp Mountain is manifest in every water-gap along its line, but more peculiarly so west of Middleport. At this point the field is suddenly increased in breadth to double its dimensions farther east, by an abrupt shifting of the Sharp Mountain range to the south. In the oblique corner formed by this offset of the conglomerate, several axes originate; and in the vicinity all the anticlinals of the western portion of the field start out, but none of them are so persistent as the Gate Ridge anticlinal and the Southern basin, whose extensive range we have just mentioned.

Figure 74 correctly illustrates the dip of the strata near Pottsville; while figure 94 represents the basin at Black Spring Gap in the Dauphin Fork. Between these points the strata change but little from the vertical, and the veins generally are so crushed and distorted that little workable coal exists in these north dips of the South basin. It is plainly evident that the contracting forces were mainly exerted on the deeper basins,—originally deeper, no doubt, but particularly so on the southern deeply-depressed strata; that is, the contracting forces were exerted on the deep

and, consequently, weaker axes, in favor of the higher and less corrugated strata, as we explained in the early pages of this work. The effects of this contracting force not only tend to depress further the already-depressed basins, but also to elevate the anticlinals or ridges.

If we take a book and lay it open about the middle before us, it will very nearly represent the strata of a gently inclining basin, the leaves being the strata. If we depress the middle, we have a representation of the action of the crust-contractions: the leaves are elevated and come together as the middle is depressed. And if we apply force to the cover, for the purpose of closing the book, we see the effects of the forces which have contracted not only our coal-basins, but a wide extent of the strata east of the Alleghanies. The axes are the weakest points, and the strata naturally fold from these points, whether anticlinal or synclinal, as a book folds or hinges on its back.

In the section presented, we have drawn a line from *m* to *n*, representing the proper or real thickness of the coal measures, or their depth as stratified in its original position. It is plain that the uptilting of the strata or depression of the synclinals naturally increases the depth of the basins, since the strata are either brought together like the leaves of a book when closed, and thus presenting the breadth of the book, instead of *half* its thickness, as the depth of the axis, or the strata are less acutely folded, and the depression filled with subsequent sediment to the water-level.

According to our measurement, the actual thickness of the anthracite coal measures is between 2000 and 2500 feet, while the actual depth of the Southern basin is over 3000 feet. This will be manifest by the sections presented. Vertical section figure 75 gives the minimum thickness of the measures at right angles: in some localities they are perhaps one-fourth greater in thickness.

THE GATE RIDGE ANTICLINAL succeeds the first, or Southern, basin. The strata here present the same appearance on their north dip as in the Sharp Mountain. A singular phenomenon is here presented of south-dipping angles on both sides of an anticlinal and also on both sides of a synclinal axis. All the strata appear to dip under the Sharp Mountain, and the veins outcropping in the Gate ridge axis *all dip south*, apparently as distinct and independent beds, though half of them are really north-dipping veins of the second basin, and only half south-dipping veins of the first basin. It will be noticed in figure 74 that the Gate vein M is also the Salem vein M,—the Gate being the north dip of the second basin, and the Salem the south dip of the first basin.

This singular formation was for a long time a mystery to our most practical miners; and even now it is rare to find any but professional men who fully comprehend this feature of the anthracite regions; for not only in this portion of the field, but in all the basins within it, many of the

north-dipping veins have the appearance of south dips on their outcrops. The same feature is manifest in the Máhanoy portion of the Middle coal-field, and it occurs sometimes, though rarely, in both the Shamokin and the Wyoming regions. We seldom find inverted strata in the south dips.

The Daddow Tunnel, which was driven south into the Sharp Mountain, a short distance above Port Carbon, about the year 1834, was the first effort to develop the veins in that side of the basin. We believe 14 beds, small and large, were cut; and though they all still dipped to the south, it was then first suggested that they eventually might change to north-dipping veins. The author preserved for a long period a section of this tunnel; but unfortunately it is now missing.

Geologists may think it strange that any difficulty should exist in explaining those irregular formations; but the geologists of that day were even more at fault than the miners, and up to a late date the errors then published still misled the scientific world; while palpable errors of a later date attest the fact that scientific men are not more exempt from this fallacy than the experimentally practical.

We think it may be justly stated that one of our old English miners was the first to suggest a theory to account for the repetition of the veins.

The first sketch ever made of the undulations of the anthracite measures was drawn by Mr. John Beadle, then managing the old Gate vein colliery for Messrs. Mann & Williams, on the walls of the mine-office; and this sketch remained on the walls of that office for years, and was often discussed and observed by many who since claim for themselves the credit of originators. We know this to be correct; and though the rough chalk-sketch alluded to did not attempt a correct delineation, it still presented the suggestion, which has since been developed in fact, and which we now present in figure 74 as the result of thirty years' inquiry and proof.

SECOND BASIN.

2. Basin No. 2, or the basin lying between the Gate anticlinal and the Mill Creek or Centreville anticlinal, has been but little developed, since none but the upper veins come to the surface. Here, at an early day, however, Col. George Shoemaker obtained from the Centreville mines the first anthracite coal successfully burned in Philadelphia. This must have been from the Lewis, Spohn, Gate, or Salem vein; for they are synonymous names for the same coal-bed.

At Mill Creek (*g*), M, on the Lewis as it is here called, has been mined for a considerable period, and the underlying veins K and L, or the Big and Little Tracy, have also been tunnelled to and worked; but all these beds are smaller here than they generally are. The Gate vein, or M, does not seem to enter the third basin on Mill Creek, but outcrops in the third on the Norwegian or the old Delaware Coal Company's tract.

THIRD BASIN.

3. THE THIRD BASIN appears to be generally a double one, but the elevation of its central axis does not bring the veins to the surface. But little mining has been done in this basin on Mill Creek, though the upper red-ash veins K, L, and M were extensively worked by the old Delaware Coal Company, at the East and West Delaware mines on the waters of Norwegian Creek.

The depth of those basins is approximately shown by the figures on the transverse section, and the general dip of the measures is also approximately shown: we will, therefore, simply refer to the illustration, without detailing further the oft-repeated vertical north dips.

4. THE FOURTH, or shaft basin of St. Clair, lies between the furnace or Delaware anticlinal and the Mine Hill, separated, however, from the latter by several minor anticlinals and small basins. This basin is, perhaps, deeper than the third, or the next one south, and is supposed to be from 1000 to 1500 feet deep, from a sudden increase in the angle or dip of the strata, south of the shaft. The fourth basin is generally wide, undulating, and gentle in its south dips, particularly in the vicinity of St. Clair and the East and West Delaware mines. But its north dip is steep and abrupt, in uniformity with all or most of the north dips in this district. All the veins, with the exception of one or two of the lowest, outcrop to the north of this basin on Mill Creek; but at Mount Laffee, the Primrose or Holmes (G & F) are the lowest outcropping veins. The Mammoth rolls over into the fifth and last basin, south of the Mine Hill.

5. THE FIFTH BASIN is an irregular one, of small dimensions. At St. Clair it is known as John's basin. Its western terminus is between St. Clair and Wadesville; but a corresponding one starts out from the north side of its western point and continues beyond Minersville. The St. Clair portion of this range of small basins continues but a short distance to the east, and a mile and a half will perhaps cover the entire range of the Mammoth in this small basin,—that is, the one east of Mill Creek, and known as John's basin. The "Seven-feet," a leader of the Mammoth, is the highest vein in this basin. But at Mount Laffee the fifth basin contains both the Holmes and the Primrose in addition.

6. THE MINE HILL BASIN is the sixth and last of the basins within the Southern coal-field, or in the Schuylkill district of the same.

This basin commences substantially on Mill Creek, above St. Clair, as its western extremity; but the underlying veins, which are small and in bad condition, run some miles farther east. The Mammoth, however, is not found east of Mill Creek.

At Coalcastle this basin is nearly, if not fully, half a mile wide, and perhaps a thousand feet deep. It is not, however, a single basin, but

contains a subordinate one, known as the Jugular "overthrow." This is a sharp, inverted basin in the vicinity of Coalcastle, lying on the north of the main basin, and along the foot of the Broad Mountain.

The Coalcastle basin and its accompanying Jugular formation are illustrated in figure 75.

Fig. 75.

MINE HILL BASIN, AT COALCASTLE.

It will be noticed in this section that the Mammoth vein basins twice; once in a regular manner in the main south basin, and again in an irregular, inverted manner to the north,—forming, to all appearances, another or distinct set of veins, which for a long period, and even to the present time, have been mistaken for a second series of large white-ash beds.

This formation gave rise to the mythical Jugular vein,—the name given to the Mammoth at Coalcastle, in the north or vertical basin. The formation is calculated to mislead, since the dips are all regularly south, and the stratification uniform. But little evidence is manifest of an anticlinal between the two basins. The upper veins outcrop, and the axis is sharp, and the rocks violently broken, so that but little evidence exists here of the overlap. At Wolf Creek, however, the evidence is clear and the proofs indisputable; and no mining engineer, familiar with our formations, would now pretend to support the "Jugular theory."

It was once supposed, from the developments made at this locality,—Coalcastle,—that a second great seam, superior to the Mammoth, and known as the Jugular, existed in the anthracite fields. Even Professor Rogers admits the theory in his great work on the Geology of Pennsylvania, without questioning its correctness.

The Mine Hill basin is about 14 miles in length; it divides at its western end, and terminates in two prongs, as formerly stated. The red-ash veins do not appear in this basin.

VERTICAL SECTION AT POTTSVILLE.

Figure 76 represents the coal measures in the deepest part of the anthracite fields. The section, however, only includes the productive strata, and terminates with the upper vein N, above which 500 feet of unproductive measures may exist. Measured in the centre of the deep basins, the distance to the first workable veins would be over a thousand feet; but this measurement could not be vertically across the strata, or at

right angles to the veins. We think our measurements are rather tending to the minimum than the maximum thickness, as a comparison with other sections would indicate.

The number of veins shown as workable beds in our section is 15, but we have only 14 distinct names, since the "Seven-Feet," immediately overlying the Mammoth, is only a leader of that great bed, and frequently incorporated with it. We have, therefore, not given it a location and a name, because its existence as a separate vein is uncertain and temporary.

The lower vein, A, though a consistent and uniform bed, varying from 2 feet to 6 feet, is not often workable. It is more frequently small and impure than otherwise.

C is likewise a rather uncertain seam, and is not often workable, but is always consistent and in place, though not always developed or noticed.

There are nine or ten small seams, ranging from eighteen to thirty inches, not considered workable, and a number of still smaller seams, not recognized or noted in mining operations. How many of these small strata exist in the coal measures we have no means of correctly ascertaining, but presume them to be from 10 to 15, and the whole number of seams, both small and large, in the anthracite measures, about 40. The 15 beds which we have given as workable coal have an average thickness of 123 feet in the Southern field, but the maximum thickness of the lower or white-ash series alone is often 104 feet. The unworkable seams contain about 27 feet of coal, and the total thickness of coal is not less than 150 feet.

We may now proceed to give a description of each bed as they occur in the column, remarking their identity with the same bed in other regions, as illustrated in our preceding sections.

FIG. 76.

ey.

or
r.

chard.

et.

h.

mtain.

VERTICAL SECTION, POTTSVILLE DISTRICT.

A, OR ALPHA.

This is the lowest consistent coal-bed in the anthracite or bituminous coal measures in the great Appalachian formations. It is frequently overlooked and neglected; but we have never examined a locality in any of the true bituminous or anthracite coal-fields in the United States where it did not exist. Occasionally it is very small, but it always occupies the same geological position as the first coextensive coal-bed in the conglomerate rocks. Where those rocks are of extraordinary thickness, even the second and third veins are enveloped in their strata; but where they are comparatively thin, this seam is either close above them, or directly on them.

Fig. 77.

A, OR ALPHA.

We not only find this seam in the anthracite regions, but it is plainly distinguished in the outlying basins of the great bituminous fields. Figure 115, representing the Sullivan county (Pennsylvania) coal, on the Loyal Lock, shows it clearly. It ranges from 2 to 4 feet in that section, and has an extensive range, but varies much in quality.

Sometimes the coal is pure and excellent in character, but frequently it is coarse and slaty. While the upper veins only exist in limited patches in those outlying basins, this small coal A, existing in the conglomerate generally, has been preserved over a much greater extent of territory, from the greater resistance offered to the denuding forces by the hard and tenacious character of this rock.

On the Great Kanawha, in West Virginia, this small seam is also plainly recognizable on the conglomerate. It is there overlaid by the vein B, corresponding in form and character to the same vein here. It is sometimes cannel in the West.

Fig. 78.

B, OR THE BUCK MOUNTAIN BED.

This is the second seam or bed of the anthracite coal measures, and is separated from A by 30 to 100 feet of strata,—sometimes almost entirely of conglomerate, with small strata of slate, but frequently by thin sandstones and slates. It is generally a large, workable bed, and is next to the Mammoth in size and character. It ranges from 8 to 20 feet in thickness; and, if we are not mistaken in our views in regard to this seam at Nanticoke and one or two other localities, it is sometimes found as large as 30 feet.

B is known best as the Buck Mountain bed, from the operations of the Buck Mountain Coal Company on this vein in the eastern end of the Hazleton basin, one of the Lehigh group. At the mines of this company

it is from 12 to 20 feet in thickness, and productive of excellent coal, which is celebrated as a superior steam fuel. In the Black Creek basin it also exists in fine condition generally, with an average thickness of 12 feet. In the Mahanoy region its general size is from 10 to 15 feet, and at Tamaqua it is given as 15 feet. In the New Boston or Broad Mountain basin,—lying between the central portion of the Southern coal-field and the Mahanoy region,—this bed is in its maximum condition. It is there 18 feet in thickness, and exceedingly pure and excellent, as shown by the sections which are presented farther on in illustration of that basin.

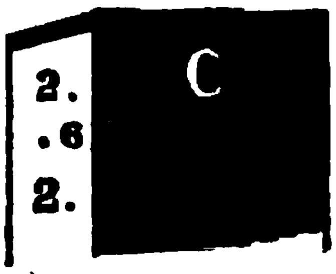
In this district it is not generally considered workable, and is not always marketable, on account of its coarse appearance. But this feature is more local than general. We may, therefore, accept B as a generally productive and prominent member of the anthracite group; in fact, we may consider this bed of much greater importance than the Mammoth, since, as a general rule, it is equally as large, and much more extensive. It is the principal bed in all the Western coal-fields, and furnishes nearly all the fuel used in the bituminous fields for the manufacture of iron. Its character is peculiar: it is almost invariably a double bed wherever found, divided by fire-clay, or slate; it always produces a red-ash coal from its lower benches; is always dense, solid, and tenacious. As an anthracite, it is our best furnace coal when pure. Its only defect is the quantity of ash which it produces; but this might be remedied to a great extent by careful selection and cleaning. In the bituminous regions it is often used raw in the furnace, when not liable to cake; but generally it is first coked or carbonized before use. It rarely ever fails to produce a good coke.

We shall refer to this bed frequently in our future descriptions of other coal-fields, and trace it by unmistakable evidences from one side of the great basin to the other.

C, OR GAMMA,

is a small and generally unimportant seam, ranging from 4 to 8 feet in thickness, and divided by slate partings, which fatally injure its value when in its minimum dimensions. In our column of this district it is small, and not considered workable; but in the New Boston basin, in the Mahanoy region, and in some of the Lehigh basins, it is of fair size and character, and may be considered productive. Were it not contrasted with our Mammoth bed, and others of more than ordinary thickness, it might be considered a good-sized bed; and were it a constituent of some of the celebrated bituminous coal-fields of England, or our Western basins, it would be considered as a large, workable seam.

Fig. 79.



C, OR GAMMA.

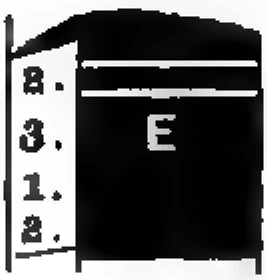
THE SKIDMORE.

D is known in this region as the Skidmore, and in the Lehigh basins as the Wharton. Its usual thickness is 8 feet, but it varies from 6 to 12 feet. It is generally considered a workable vein in all parts of the anthracite regions, and productive of fair merchantable coal. It contains some impurities, but the bone and slate partings are concentrated in sections, or benches, and are, consequently, more readily separated from the coal than when those impurities are promiscuously scattered through the coal. There is nothing peculiar about this bed to note especially, except that it immediately preceded the formation of the grand and celebrated Mammoth, from which it is separated by from 30 to 100 feet of slates and sandstones. In the Northern coal-field, Scranton district, D is only 22 feet below the Mammoth, while at Carbondale it is merely separated by a few feet of slate, and forms part of the Mammoth. In that region the veins are all distinctly shown, but they are divided by comparatively thin strata, and the veins themselves are considerably diminished, *vide* figure 25.

Fig. 80.

D, OR SKIDMORE.

Fig. 81.



E, OR MAMMOTH.

THE MAMMOTH.

This is the great bed of the anthracite coal-fields, and perhaps, considering its extent and frequent enlargements, the most magnificent coal-bed in the world. Its most productive or best condition is perhaps thirty feet in thickness; but it varies from 12 to 70 feet. In figure 81 we have given it as 25, which may be accepted as its average size in this district. In the Lehigh district it ranges from 40 to 60, but contains less workable coal than it does when only 30 feet thick, as in the Lehigh detached basins and elsewhere. In the New Boston basin it is over 60 feet thick, vertically across the strata of the coal, while the bed is uniformly deposited in a moderately dipping basin. Generally, those great enlargements are on an axis of formation, either synclinal or anticlinal, where the vein is doubled, and, consequently, the benches are counted twice. But in the New Boston basin such is not the case. The vein is evenly stratified and single. In the Mahanoy region the average size of the Mammoth is from 25 to 30 feet in thickness; but there, as elsewhere, several great enlargements are found. One of these is at the McNeal col-

liery, where the vein is over 50 feet thick, and another is at Shenandoah City, where it is between 70 and 80 feet thick. But both these excessive dimensions are on the vertical north dips, where the vein is probably doubled. In the Shamokin region the Mammoth is divided, and is known as the Twin veins. Each division ranges from 9 to 16 feet in thickness, and is divided by from 10 to 40 feet of slate and sandstone. In the Lehigh basins its size is generally uniform, and ranges from 25 to 35 feet, and the bed is in fine condition.

In the Wilkesbarre district of the Northern coal-field, the Mammoth, under the name of the Baltimore vein, is about 20 feet thick; in the Pittston district about 12, and the Scranton 14 feet. At Carbondale it is 20 feet thick; but there it is composed of several of the accompanying veins, brought together by the thinning of the strata in that direction.

A peculiar and favorable feature of the Mammoth is its massive and solid benches of pure coal, which frequently exceed four feet without a streak of bone or impurity, and often from ten to twelve feet without any marked parting of bone or slate to denote a change or interval in the process of formation. We cannot conceive any possible or probable process by which these masses of coal could have been formed by arborescent vegetation. It is simply impossible. We are forced, therefore, to more natural conclusions, or such as we discussed pretty fully in the opening chapters.

The Mammoth vein now produces over two-thirds of all the anthracite coal mined; and perhaps we might increase the amount without over-estimating it. As long as the Mammoth bed is productive at moderate depths, the smaller seams will remain in *statu quo*. The difference in the cost of mining coal from those large white-ash beds or from the small red-ash seams cannot be less than 50 per cent., and, including risk from faults and irregularities, perhaps much more. The Mammoth is the most regular and reliable of all our veins, the most economical to mine and operate, and, from its size, the most productive.

The "Seven-Foot Vein" is a leader or satellite of the Mammoth. It is generally persistent throughout the Pottsville district, and usually found in the Mahanoy region; but generally in other sections it is combined with the Mammoth. Its size varies from 4 to 10 feet, and its character is generally rather coarse and bony. We do not consider it a regular bed, for the reasons before mentioned. Its distance above the Mammoth varies from 0 to 20 feet. The latter is its usual position in the Pottsville and Mahanoy districts.

The identity of the anthracite with the bituminous coal-beds can no doubt be made; but we do not think our miners and mining engineers have begun right, nor do we think it possible to identify them if the Pittsburg seam is taken as cotemporaneous, or on the same horizon with the Mammoth, for reasons which we may briefly explain.

In the first place, the average distance of the Mammoth from the conglomerate is not over 300 to 400 feet, while the Pittsburg seam is from 700 to 800 feet. Now, as it is remarkable that the strata invariably depreciate or thin in a western direction, it would be singular and at variance with all our experience if the strata between the Pittsburg seam and the conglomerate should be greater at the Ohio than at the Schuylkill.

Secondly, we find the Pittsburg seam on the top of the barren measures, while the Mammoth is at their base, and the Primrose here occupies the place of the Pittsburg there. The great Mahoning sandstone seems cotemporaneous with the massive sandstone over the Mammoth; and the Holmes, or F, corresponds with the single small seam in the "barren measures."

Third, we find in the detached coal-basins lying between the anthracite and bituminous fields, the Mammoth in its proper position and character, as shown by figure 115, representing the Sullivan county coal-basin, which we give from actual and personal measurement.

We find the Mammoth also in its proper place in the Cumberland region, with the usual underlying seams; and we find, also, that the great bed of Karthause and Clearfield, in Pennsylvania, which is at the base of the barren measures, corresponds with the Mammoth in position and general characteristics; while we find the same bed on the Great Kanawha and on Coal River, in West Virginia, in the relative position of the Mammoth, and corresponding more generally with that great bed than the Pittsburg seam.

We are, therefore, forced to conclude that the first large seam below the barren measures, and on the same horizon with the Mammoth, is cotemporaneous with the latter, and that the Primrose bed, which is on top of the barren measures, and on the same horizon with the Pittsburg seam, is cotemporaneous and identical with the latter.

Under this theory it is possible to reconcile the anthracite with the bituminous formations; but it is not possible under the theory which takes for granted that the Mammoth and the Pittsburg seam are synonymous, nor under another theory, which makes the Mammoth identical with B in the Western coal-fields.*

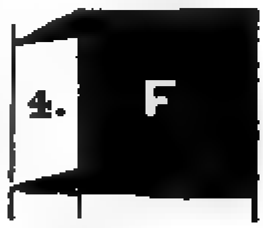
THE HOLMES.

F is a small seam overlying the Mammoth about 200 feet. It ranges from 3 to 5 feet in thickness in the anthracite regions, and, if we are correct in our conclusions, from 6 to 30 inches in the bituminous coal-

* There is much difference of opinion in regard to the true horizon of these respective beds. Lesley makes the Pittsburg and Cumberland 14-feet bed identical; while Lesquereux thinks the Pittsburg above our red-ash beds. Lesley and Lesquereux, however, are both correct in the main points of the identity; and farther on we have made use of their evidence to prove our proposition. The general impression among miners is erroneous.

basins, and is located between the upper and lower coal series, and in what is known as the "barren measures" in the Great Alleghany coal-field. It is not much worked, and is considered small and insignificant in comparison with other great accompanying beds. The coal is generally good, and the seam is consistent and uniform.

Fig. 82.



F, OR HOLMES.

Strictly speaking, this is the upper white-ash bed. But we may here remark that which we omitted in the proper place,—that the lower bench of the Buck Mountain, or B, produces a dark red-ash, and A produces red-ash entirely.

THE PRIMROSE.

The Primrose is a large and productive bed, generally regular and reliable in character, and is mined with economy. It ranges from 9 to 16 feet in thickness, and is generally classed with the white-ash beds, though it is more properly a pink-ash. The bottom bench is a white-ash coal, and the upper benches red-ash coal. In other regions, however, it produces all white-ash coal, and is considered as among the white-ash veins, and particularly so in the Mahanoy region and in the Scranton district, where this vein is very large and productive. It lies from 300 to 400 feet above the Mammoth. We consider the Primrose as the counterpart of the Pittsburg seam, since it occupies a corresponding position in the horizon of the coal measures, and is generally identical with the Pittsburg in character, position, and associations.

Fig. 83.

G, OR PRIMROSE.

The Primrose is the most consistent bed in the anthracite coal-fields, and is, in all probability, equally consistent in the bituminous regions. Its variations are not so great as the Mammoth, and it appears to have been formed with less interruption, since it is rare to find more than one slate parting in it, and frequently there is none, the divisions being merely partings of bone or coarse coal; while the Mammoth is frequently divided by massive slates or sandstones from 2 to 40 feet in thickness, and is often divided into four distinct veins,—that is, the upper or "seven-feet vein," the upper "Twin," the lower "Twin," and the "cross-cut,"—and these, in all probability, form the chief veins, independent of the Buck Mountain, or B, in the bituminous regions beneath the barren measures.

All the lower beds, including the Mammoth, are subject to sudden and excessive expansions and contractions. The Mammoth is found at one place over 60 feet thick, in regular and uniform strata,—for instance, at New Boston; and at another it is found depreciated to two thin plates of less than 6 feet respective thickness, or 12 feet, which is the minimum

thickness, near Shamokin. These sizes may be regarded as the minimum and maximum changes, and between them this great bed vibrates from point to point; but its most persistent size is between the extremes of 20 and 35 feet, which is its best condition.

The Primrose, or G, is less changeable. Its size or diameter is usually —almost uniformly—10 feet, though it varies from 9 to 16 feet when in measures not confused and contracted by faults; but in faulty ground this bed, like all others, is liable to extreme fluctuation.

It is worthy of note, and we may perhaps appropriately state the fact here, that all beds of coal formed in extremely deep basins are smaller than when formed in moderately deep basins. We think this rule will hold good the world over. But they are still thinner and much more unreliable when formed in extremely shallow basins than when formed in the extremely deep basins; and this fact is a very strong argument against the theory which makes our coal-beds the productions of arborescent or marsh and bog vegetation.

For fear of misconception, it may be necessary here to remark that many of our present deep beds were not the primary formations of deep basins. They have been subsequently depressed, as is evident from the actual thickness of the strata at right angles and the absence of the upper veins, which are conclusive evidences of their original depth and of their subsequent changes.

The deep basins of the Mahanoy, with their sharp angles and narrow troughs, were not formed in their present position, but have since been contracted and depressed; and we may say the same thing of the Lehigh formations generally. But the central portions of the Shamokin and Pottsville basins must have been deep originally, and some of the wide basins of the Western bituminous coal-fields must also have been extremely deep, as were the formations of the Great Northern coal-field of England and the Arcadian coal-fields of the British Provinces.

Fig. 84.

This subject requires more elaboration and proof to make it intelligible. This, however, is not the place to discuss it; but we briefly mention the fact here, as we find it abundantly illustrated by a hundred concurring evidences.

THE ORCHARD.

H, OR ORCHARD.

The Orchard, or H, is a regular and uniform bed. It ranges from 4 to 8 feet in thickness, and lies about 100 feet above the Primrose, or G. It is the first purely red-ash vein; but the coal is frequently coarse and unprepossessing in appearance, though an excellent fuel for domestic purposes. When a boy, and engaged in work-

ing this coal at Oak Hill, the author remembers to have heard James Silliman, Esq., of Pottsville, call it "hemlock coal," in allusion to its vegetable origin and the coarse-grained, knotty character of our hemlock or spruce timber. But this is not a general characteristic of H. We have seen it productive of the most beautiful and lustrous red-ash coal. It is always divided by a parting of slate, or soft, "dirty mining," from 3 to 6 inches thick. The bottom bench ranges from one to two feet, and is generally of pure coal, though frequently of thin layers from two to three inches in thickness. The top bench ranges from 3 to 5 feet in thickness, and is more massive in character, though often streaked with bone and divided into layers or strata of from 6 to 12 inches in thickness.

THE LITTLE ORCHARD.

FIG. 85.

I, OR LITTLE ORCHARD.

The Little Orchard is a small seam, and but little worked. It ranges from 2 to 4 feet in thickness, and lies about 150 feet above the Primrose, in the Pottsville district; but this and the Big Orchard, H, is frequently found from 200 to 250 feet over the Primrose in other districts. At Scranton, however, H is only 92 feet above G; but, as before observed, all the measures *thin* in that direction. We may here remark that I is not a consistent and uniform seam; and we think it very probable that we have on several occasions, in other sections, given I the credit which is due to J. In the Scranton district we think it probable that I either unites with H or disappears entirely, and that J takes its place.

This little vein sometimes produces the most splendid coal when in its maximum condition; but when small its coal is tough, coarse, and profusely streaked with bone and sulphur. Its variations are sudden and extreme; and when its expansion is from the miner it is very difficult to mine, from its tendency to "jam" in a wedge-like manner.

THE DIAMOND, OR DADDOW.

FIG. 86.

J, DIAMOND, OR DADDOW.

This is one of the larger and persistent red-ash beds, and is found uniform in character throughout the red-ash formations or upper series of the coal measures. It ranges from 5 to 9 feet in thickness, and lies from 250 to 300 feet above H, or from 400 to 500 feet above the Primrose, G, across the measures, at right angles with their dip.

This vein is known locally by a variety of names, as the "North Diamond," "Flowery Field," "Peacock," &c., and has

been extensively worked at Oak Hill, on the West Norwegian, by the writer's father, and others. When in its best condition, it is productive of the most excellent, prepossessing, and lustrous coal, and is appropriately named the "Diamond," since none of the red-ash coals have a more splendid appearance. But, unfortunately, this vein is not reliable. It is subject to "faults" and irregularities, and frequently changes suddenly from the purest coal to a dull mixture of dirt, slate, bone, and coal. These faults, however, are not very extensive, and in a large operation the impure portions might be left as pillars without much loss; but, under present circumstances, mining on a large scale cannot be profitably conducted on the red-ash seams in competition with the great white-ash beds, which are mined with much more economy. Small amounts of red-ash coal may find a market at reasonable or remunerative prices; but large quantities would come in opposition with the white-ash markets. The day has not yet arrived when the red-ash veins can be worked with profit; but it will come, as surely as the exhaustion of the Mammoth at moderate "sloping" distances from the surface. When deep shafts are necessary to reach the Mammoth, the red-ash seams must be penetrated; and they will then be worked to some advantage.

The Diamond is, we believe, invariably divided into two "benches," generally by a soft "mining," which sometimes, however, changes to slate and bone. The bottom bench is hard, lustrous, and pure, and generally solid, with a conchoidal fracture. Its thickness ranges from 2 to 4 feet. The dividing portion is from 4 to 10 inches in thickness, and the upper bench or benches from 3 to 4 feet in thickness, and is often shelly and soft, productive of much waste. Though easily mined, it is not always remunerative, on account of the large amount of refuse, which must be handled, and which frequently is more than can be stowed away in the excavated portions of the mine.

THE BIG TRACY.

FIG. 87.

K, OR THE BIG TRACY

Figure 87 does not represent the Big Tracy in its best condition, but we think it about the mean, or an average illustration of its character. We have attempted to project all the sections of coal-strata on a scale of one-tenth of an inch to a foot; and this scale will approximate the actual thickness. But we have given the figures in all cases; though our artist, who is usually very correct, has not always put the distinguishing marks to denote feet from inches. A *dot* after the figure should denote feet, and before it inches. With this explanation the reader will be able to detect the error.

The Big Tracy, or K, ranges from 8 to 12 feet in thickness, and lies from 200 to 250 feet above the Diamond, or J; but between them there are two or three veins approaching the workable sizes, and among these is the "Clinton," which ranges from 2 to 3 feet in thickness.

We have represented this bed as divided or streaked with several benches of bone, and accompanied with a soft stratum or mining as a base; but this condition is changeable, and the vein is frequently found almost pure, or with but small strings of bone; when the bone is wanting, some of the upper benches are generally soft and shelly, and productive of much waste in mining and the preparation for market.

This bed is also liable to "faults;" and perhaps one-fourth of the entire area occupied by its strata will be found unproductive. The general form of *fault* or imperfection developed by the workings on this bed is a tendency to crumble or waste. A considerable portion of the seam, under such circumstances, cannot be made available. "Dirt-faults," as represented in figures 111 and 112, are frequent in all the red-ash coal-beds; while rock-faults, as illustrated in figures 108 and 110, are more frequent in the white-ash beds.

It may be noticed, by an inspection of the transverse section across the field at Pottsville, and the several vertical sections taken in various parts of the anthracite regions, that K occupies but a small portion of this territory. (See figure 74.) It is only found in the first four basins in the Schuylkill district, and does not extend to Tamaqua or Tremont; while it is not found in any of the other fields, except, it may be, in some portions of the Shamokin region.

THE LITTLE TRACY.

The Little Tracy is a solid bed of excellent coal. It is seldom faulty or impure, but it varies considerably in size, ranging generally between 3 and 4 feet, but sometimes depreciates to 12 inches, and has been known to exceed 5 feet in thickness. This coal, when the seam is in good condition, presents an admirable appearance, and as a fuel for grates or household purposes cannot be excelled.

FIG. 88.

L, OR THE LITTLE TRACY.

The vein is worked with much economy when in its average size, considering its diameter, and produces but little waste, and, except a single bone which accompanies the coal, there is no impurity; and this bone, owing to its solidity, is easily separated from the coal without injuring its marketable qualities.

A stratum of "mining" generally underlies the coal-bed as a base. It is usually soft dirt, and presents an advantage to the miner for the purpose of "undermining" the coal; that is, the miner digs out this soft stratum from under the coal, and thus leaves it without support except by its con-

nection with the seam at the edges. This undermining process, therefore, enables the miner to break down the coal with powder or wedges with much more facility than it can be obtained when solid. It is thus we call these soft strata "mining," because in them the miner "undermines" the coal in the anthracite mines whenever available: they frequently occur in the upper red-ash seams, but seldom in the white-ash. In the latter the "blasting" process with powder is exclusively made use of.

Bituminous coal-seams seldom contain any softer stratum than the coal itself. Frequently, bands of slate traverse the coal; but these are generally harder than the coal, and, consequently, are not available as mining. The miners usually cut out the lower portion of the seam in the bituminous coals, not only with more labor than is required in digging out our soft strata of mining, but also with much waste of otherwise marketable coal. But this mining process is the most available one known, and is invariably made use of in the English mines, and in all bituminous regions where the mining of coal is conducted systematically and economically.

There is not much difference in the relative sizes of L and I; but there is considerable difference in the economy of working the two seams, as I contains no "mining" stratum, and the coal is therefore "blasted" from the solid with powder, without the great advantage of being undermined, as in L.

The Little Tracy, or L, is sometimes known as the Little Diamond, from the great purity and lustre of its coal. It is also known as the "yard coal," from its size, "Mason's," "Rabbit-hole," "Charley Potts," "Radcliffe," "Palmer," &c. Its position is from 50 to 100 feet over the Big Tracy, K, and 150 below the Gate, or M.

THE GATE.

This is the upper reliable seam in the anthracite regions, and is perhaps the most valuable of the strictly red-ash veins above the Primrose. It is extensively worked, and has been mined to a great depth at several distinct and distant localities,—for instance, at the York Farm, by George H. Potts; at the Old Salem colliery, near Port Carbon; at the Novelty colliery, below New Philadelphia, and several other points,—and has generally been found consistent, uniform, and less troubled with faults than most of the red-ash beds of an earlier formation,—a singularity that we can scarcely account for except by the theory of "gradual depression."

Fig. 89.

K, OR THE GATE.

This seam ranges from 4 to 16 feet in thickness; but its usual and best condition is from 5 to 10 feet. The south dips, though more consistent in

size, are generally the smallest in diameter; while the north dips are usually of greater dimensions, but generally not so reliable or regular. A singular feature of this seam is the fact that a north dip is seldom found on the surface or at its outcrops. This feature, however, to a limited extent, prevails with the veins immediately below it, and to the same extent to the one above it. This is readily explained by referring to figure 74, where it may be noticed that all the north dips incline at first to the south in the first basin; and this feature governs the upper seams to a greater extent than our section represents, even in the third and fourth basins. In fact, nearly all the north dips in the Pottsville district are either inverted or perpendicular: consequently, the outcrops of nearly all the seams would appear as if they were dipping to the south; and this feature originally, or when this field was first developed, was a great mystery to geologists and miners. Those who knew little or nothing of geology supposed that we had as many distinct seams as we had outcrops, and that instead of 14 workable beds we had 140 or more. Whether they all united in a great mass below, terminated in needle-points, cut each other off, or dipped under the Sharp Mountain and came up in some other unknown country, were debatable questions which were often argued, but we believe never satisfactorily settled or concluded.

We believe that M was first worked at Centreville, under the name of the "Sphon," and subsequently at Pottsville, in the Gate ridge, under the name of the Gate; at the Salem colliery, near Port Carbon, as the Salem; at the Delaware mines, as the Peach Mountain; and at the Mill Creek colliery, as the Lewis. At each of these points this vein was worked in different basins and on different dips, and under different names as distinct seams. Even now many of our old and intelligent miners are slow to credit the fact. To them it seems inconsistent that the Gate and Salem can be the same vein, since they both appear to dip in the same direction and are apparently in the same basin. It is difficult to convey an intelligent impression of the inverted dips in our anthracite basins to the minds of men accustomed to the uniform and gentle undulations of the English coal-fields; but we hope our illustrations will convey the idea more successfully than our simple descriptions.

This feature of inverted dips has not only mystified the formation in the southern or deep basins below the red-ash seams, but has been the cause of much confusion and error in connection with the Mammoth in the white-ash or northern basins. Thus, the inverted dip of the Mammoth at Coalcastle, as illustrated in figure 75, gave rise to the fabulous Jugular bed which has been the means of draining the pockets of many. But the Jugular has never been found; though some are still driving tunnels in search of it. They may be rewarded by the discovery of the Buck

Mountain, or B, in a workable condition; but, as the famous Jugular is a myth, its believers will never be rewarded for their faith.

The Gate, or M, has, of course, less range than the Tracy, or K, before described, and probably does not cover more than 60 square miles of area throughout the anthracite regions. Its superficial area, however, is less than its real area, if horizontally stratified, since the basins in which it exist are contracted to less than half their original dimensions, until the veins are frequently "on end," instead of being in a naturally stratified basin. At the Roads Shaft colliery, near New Philadelphia, M is found dipping at the rate of 80° south, while in the Sharp Mountain, opposite, this bed is perpendicular and frequently inverted. It is almost impossible, under such circumstances, to tell how deep the basin may be, or how wide it originally was. But this contraction does not take place in shallow basins; for, instead of being depressed, they are lifted by the contracting forces, and we may thence conclude that all perpendicular dips having *long axes* must belong to deep basins.

The Gate at the Roads colliery will average 10 feet thick, with 7 feet bottom bench, and a 2 feet top bench, divided by a foot or more of slate.

THE SANDROCK.

FIG. 90.

N, OR THE SANDROCK.

This is the upper workable seam in the anthracite measures; but it is generally considered too small for attention at present, though we believe it has been worked as the South Salem. It ranges from 2 to 4 feet, and lies from 100 to 150 feet above the Salem, or M. N is worthy of note simply as the upper workable seam, but otherwise it is insignificant, and scarcely deserves a name and location among the many magnificent beds which we have illustrated: inclusive, however, it constitutes the fifteenth seam.

To all of these, except A and C, we have attached the most popular name, and have frequently given the local names as applied in different districts. We may here note an omission, however, in case of the Mammoth, which was known generally during the early development of the Coalcastle or Mine Hill basin as the "Daniel," after the first operator, Mr. Francis Daniel, now of Yatesville, in the Mahanoy valley.

We have given names to the two lower nameless beds A and C, as Alpha and Gamma. These, however, are unimportant seams, and no one will be concerned about their names. The liberty we have taken in giving them some definite title is simply for convenience.

The names and thickness of the respective seams as we have now classified them, in the Pottsville district, we give in the accompanying table.

	Name.	Thickness of Seams.		Thickness of Measures.		
		Max.	Min.	Max.	Min.	
		Ft.	Ft.	Ft.	Ft.	
A	Alpha............	4	1	50	10	The average thickness of both seams and measures is given in figure 74, or the Pottsville section.
B	Buck Mountain.	30	6	75	35	
C	Gamma..........	8	2	[illegible]	40	
D	Skidmore........	12	4	150	40	
E	Mammoth........	75	12	100	22	
F	Holmes..........	6	3	300	[illegible]	
G	Primrose.........	16	6	150	[illegible]	
H	Orchard..........	[illegible]	4	[illegible]	92	
I	Little Orchard..	4	2	100	21	
J	Diamond.........	10	5	300	35	
K	Tracy............	12	6	[illegible]	150	The minimum column to this point is taken from the Scranton section; below this, from the Pottsville.
L	Little Tracy.....	4	2	100	50	
M	Gate...............	16	6	[illegible]	150	
N	Sandrock........	4	2	150	100	Alpha is the lowest and the Sandrock is the highest seam.
	Total.........	205	[illegible]	2175	820	

Thus the minimum thickness of the coal-seams would be about 60 feet, the average thickness 123, as given in figure 74, and the maximum 205 feet. The thickness of the measures would stand thus, inclusive of the coal:—minimum, 880; average, 1750; maximum, 2380. These figures merely represent the distances from the lower to the upper coal-seam, or from A to N. The unproductive measures above N may vary from 300 to 1000 feet, according to location and situation.

SWATARA DISTRICT.

In proceeding westward, we shall briefly notice a few of the chief or distinguishing formations, and shall not reiterate that which we have already stated concerning the seams and their peculiarities, since there is a general sameness of the measures from Pottsville to Tremont, and the number of basins there is, perhaps, not less than between the Mine Hill and the Sharp

FIG. 91.

TRANSVERSE SECTION AT SWATARA.

Mountain, as figure 91 partially illustrates. Three basins are represented, looking west. The right of the view is along the line of the Mine Hill range, and the two northern basins may be considered as in it. To the

south of these there are three basins, part of one only being represented which divides this portion of the field into five basins.

The first basin, counting from the south, or the Sharp Mountain, is a continuation of the Pottsville axis; and it is probable that the remaining basins are parallel axes, starting out from the same point, though subject to many changes and modifications between the points, such as the "shifting" of the anticlinals from right to left, and *vice versâ*, and the elevation and depression of the synclinals, as explained in the case of the first basin, south of the Mine Hill. Beyond this point the axes divide, the north anticlinals turning northwest, the south axes pursuing their course without much change. This deflection soon accomplishes a division of the field, and forms the north and south forks, formerly described.

The first basin south of the Mine Hill, which we partially represent in figure 91, continues into and throughout the Lykens Valley, or North Fork; and the same may be said of the second or middle basin. But at or near this point a new basin commences, which widens and undulates in minor rolls westward, until it terminates in a short point between the forks. The south basin, as already observed, forms the South or Dauphin Fork, which is a single basin; while the north is a double basin, as intimated by a continuation of the two basins before mentioned. A third basin is, however, developed at Bear Gap; but where this commences we have been unable to ascertain.

The two small north basins, containing the "seven-foot" as the upper seam, terminate a short distance west of Swatara Falls. The veins are here found in their places uniformly, as shown by the letters; but we are not informed whether all the lower beds have been developed. Col. D. Percy Brown, who furnished the data for this section, had not made any developments below the Skidmore. We are informed, however, that B exists a short distance to the east, at the Forestville mines, and therefore assume that it must exist here. A clear statement is given of the seams from D to J.

The Skidmore is here 6 feet thick, and lies about 50 feet below the Mammoth. The Mammoth itself is divided by 45 feet of slate and sandstone,—the lower bed being 6 feet thick, and the upper bed 16 feet; while its satellite, the "seven-foot," is 40 feet above the upper bed, and is about seven feet in thickness. The Holmes and Primrose, or F and G, are in their proper positions; the Primrose being 145 yards in horizontal distance across the measures—which dip at 45°—from the lower bed of E, or the Mammoth.

The Orchards H and L, and the Diamond J, are found "in place" above G; but these appear to be the highest seams in this basin. The two southern basins probably contain the Tracys, or K and L, at this point, as the highest beds of workable coal.

A gradual thinning process appears to take place in the seams south of Pottsville, while the Mammoth permanently divides, and forms three distinct seams. At Tamaqua, and east of that point, the seven-feet seam does not make its appearance; but a short distance west a thin seam starts off from the Mammoth and forms an independent bed, which never again unites with the Mammoth. At Mount Laffee another split of the Mammoth takes place, which widens in its westward course until, at Swatara, as we have just mentioned, they are 45 feet apart. Thus this great bed forms three separate and distinct seams as it goes west; and these undoubtedly continue through the Western bituminous coal-fields. We have reason to believe that both C and D depreciate westward, as all our sections indicate, and that they are small and insignificant seams at Broad Top, and perhaps obsolete in some of the Western fields; and we have, likewise, evidence that B divides in the same manner as E, and forms two distinct seams in its westward course,—which, we think, can be distinctly recognized in many parts of the bituminous regions. It is a very significant fact that all the lower seams in the Alleghany coal-fields exist in *pairs*, or double beds,—which sustains our theory that the Mammoth and all the white-ash coals, strictly speaking, of the anthracite regions lie below the Mahanoy sandstone, and the barren measures of the Western coal-fields. The Twin seams of Kentucky are on the same horizon with B here, which is always, or with rare exceptions, a twin seam.

The same comparison or analogy holds good in the Middle anthracite region, taking the Lehigh basins as the eastern starting-point, where the Mammoth is a single bed of from 25 to 35 feet in thickness; but in the Mahanoy region it throws off the "seven-feet,"—at first small, but increasing westward to a maximum of 10 feet. Westward of the Locust dividing ridge the Mammoth again divides and forms the "Twin veins," at first with only a few feet of dividing slate; but before it reaches the western termination of the Shamokin region, at Trevorton, those seams are divided by a hundred feet or more of measures, and are considered as distinct seams.

In the Wyoming region we do not recognize the Mammoth at the western extremity of the region. It does not exist. But there, as here, the seams divide, in the vicinity of Nanticoke, and form separate beds from that point westward.

In the Broad Top region, which lies almost in a direct west course from the Wyoming field, we cannot recognize the Mammoth, or reconcile the seams to our central formations in the anthracite regions; but there is no difficulty if we take our western divisions as a guide, and seek only for the larger seams, since the smaller ones depreciate to mere leaders or streaks, and eventually disappear entirely. But in the Broad Top field we find the representation of every seam which we find here, with the exception of the

"seven-feet," which, however, entirely disappears before reaching the western end of the anthracite fields in the Middle coal-field, and does not appear in the Northern, or Wyoming, field.

Section of Broad Top Measure.

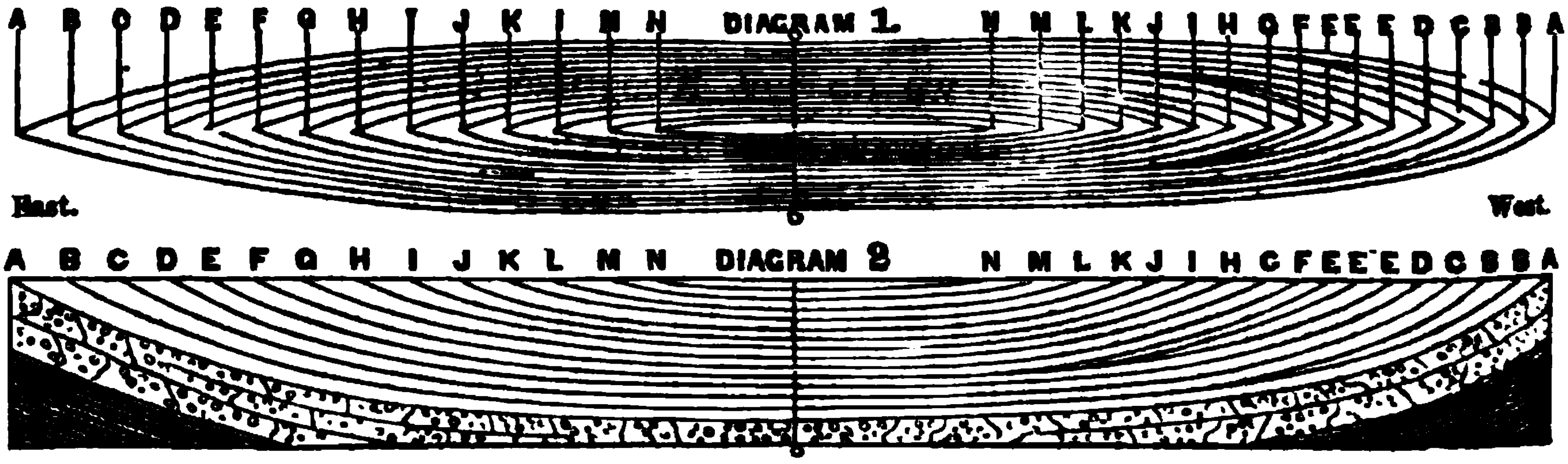
Mahanoy sandstone, &c.	150	Coal, B, Buck Mountain	5
Coal, E, Mammoth or Freeport	5	Slates, sandstones, &c.	35
Slates, &c.	50	Coal, Leader	1
Coal, E, Mammoth or Freeport	7	Slates, &c.	30
Slates, &c.	30	Coal, B, Buck Mountain or Lower Bed	7
Iron ore	1	Sandstones, slates, &c.	35
Coal, D	1	Coal,* A	1
Slates, &c.	50	Slates, &c.	30
Coal, C	1	Conglomerate	100
Slates, &c.	10		

NORTH, OR LYKENS VALLEY, FORK.

Passing west of Tremont and entering the basin of the North Fork, or Bear Valley, we soon lose all traces of the upper or red-ash seams; and the lower, or white-ash, also terminate with the measures in which they exist, as they successively rise to the surface. As we have stated, all our coal-fields exist as long, narrow troughs, with their extremities rising, like the ends of a canoe, to a point at the surface, as plainly illustrated in figure 22, representing the east-and-west undulations of the Wyoming basins. While the central portions of the field contain 15 seams, the extremities contain but one; and while the lowest bed at Pottsville may be 3000 feet deep, the lowest on the end of Short Mountain, west of Wiconisco, may not be over 20 to 30 feet.

The Gate vein, M, may be near the surface east of New Philadelphia

FIG. 92.



PLAN OF OUTCROPS.

and west of Swatara, but it ends near those points and traverses less than

* This seam is more frequently found in the conglomerate than above it.

half the length of the field; and between these points and the extremities all the underlying seams come to day, or outcrop. This may be illustrated more clearly by the small diagram, figure 92. The practical—those familiar with our coal formations—will not require the aid of this figure to comprehend our description; but there are many who will require the aid of this plan, which shows very plainly why there are more coal-seams in the centre than at the extremities of the basins.

This illustration does not merely represent the outcrops of the seams in the north or Lykens Valley arm of the Southern coal-field, but is a general plan of the terminations and outcrops of the coal-seams in each basin. We have not given the parallel basins in each field as they exist side by side. It would be a mere repetition, and would tend to confuse rather than to instruct. We should be glad to see a correct representation of the position and outcrops of the respective basins in the First, or Southern, coal-field, for we confess ourselves unable to construct one. In fact, we know it to be impossible under present developments. An ideal plan might be constructed, representing the general features and groups of the Southern basins; but it would only be understood by those practically familiar with the peculiarities of the anthracite formations. We may, however, convey a faint impression by comparing the basins in the First, or Southern, anthracite field to a fleet of Indian canoes laid side by side in a narrow stream. But some of these canoes should be very long and narrow, and others very short and comparatively wide; and, to complete the comparison, while they should lie seven or eight abreast in the centre, two should lie at the west end of the fleet, wide asunder, and only one at the east end.

The proportions in figure 92 are not correctly drawn, but it would be impossible to represent the formation on a natural or uniform scale. While the basin thus represented is not less than 70 miles long, it is only from a half-mile to a mile in breadth,—taking the first basin of the first coal-field for instance,—and only 3000 feet deep, assuming their centres to be from 0 to 0 in the vicinity of Pottsville.

We have thus, perhaps, digressed from the subject under discussion, but have, we hope, conveyed a good idea of the general character of those terminating basins; and we shall not be required to state further why there are only two or three workable seams at Wiconisco and fifteen at Pottsville.

The Bear Valley seems to be a double basin, but in reality the measures contain three basins; they are not, however, all in Bear Valley. In fact, in Bear Gap, at Wiconisco, only one basin is shown in the valley; while the other two basins are, in a manner, under the mountains,—the south basin being under the southern base of Big Lick Mountain, and the northern basin being at or near the north base of Short Mountain.

We are aware the miners of Wiconisco think differently, and are under the impression that their coal-seams are *below the conglomerate,* forming a single basin from north to south under the valley and under both mountains. But, if such is the case, all we have written is wrong, all our geology is at fault, and science has blundered seriously in the anthracite regions.

Any one familiar with our inverted dips and the peculiarities of the Shenandoah City, Coalcastle, Sharp Mountain, and other local irregularities, will comprehend at a glance the Wiconisco formation. There is no place, however, in the anthracite coal-regions so perplexing as this to the mere local observer: the more he investigates, the more will he be perplexed and mystified.

We have attempted to give an illustration in figure 93; but it is very difficult to convey a good impression of this singularly-contorted strata by word or design. If we are correct,—and we think there can be no doubt of it, for no other explanation is available,—the strata here are more inverted than at any other locality in the anthracite regions, and much like some of the inverted dips of the Blue Ridge formations in Virginia, or the gneissic strata at many points along the Atlantic slopes.

FIG. 93.

TRANSVERSE SECTION AT WICONISCO.

We do not pretend to give an exact delineation in figure 93, nor is it drawn to a correct and uniform scale; but we believe it to be generally a fair section across the coal formations of the North Fork at Bear Gap.

We would, however, call attention to one error, which has escaped our notice until too late to remedy it. The red shale ought to be represented between the conglomerates of the north and middle basins, where the thickness of this rock is, in consequence of this omission, much greater in appearance than it really is. We may also state that the lines drawn near the mouth of the tunnel, south of the middle basin, should represent conglomerate. With this explanation, the formation justifies, and the whole will appear plain.

This arm of the coal-field appears to have been originally a wide and rather shallow formation, containing three distinct basins: the middle one being smaller and much shallower than the outside basins. The process of contraction, while it forced those basins closer together and elevated their edges, did not depress their centres, but, on the contrary, elevated the

whole mass, and, of course, affected the middle basin less than the deeper and longer outside basins.

The mines at Wiconisco are not deep; though we believe one slope is 600 feet long. Our notes say 300 feet; but our impression is that one of the slopes is of the above length, on an angle of about 25°. How far it may be to the bottom of this, the south or left-hand basin, we cannot say, but presume it cannot be less than 1500 feet. The miners and engineers of this place believe it to extend under the entire section, as shown by the dotted line. There are three seams in those basins, but only two are considered workable: their dimensions are respectively 5 and 11 feet. The coal is *red-ash,*—which proves them to be the lower beds; and we doubt not both belong to B, or the Buck Mountain bed, in its divided condition. This seam is always a red-ash in the anthracite regions, and, we understand, sometimes also in the bituminous fields; while the seams above B and below G are white-ash, and all above G, and sometimes inclusive of G, are red-ash,—or there are 10 red-ash seams and only 5 white-ash beds; but, nevertheless, there is perhaps more white-ash than red-ash coal, on account of the greater thickness of the Mammoth and the greater extent of the white-ash than the red-ash area, as may be noticed in figure 92, excepting the lower red-ash seams B and A, which occupy still larger areas.

THE SOUTH, OR DAUPHIN, FORK.

This fork, or arm, of the Southern coal-field is a long, deep, narrow, and single basin, being a continuation of the First, or Pottsville, basin, parallel with the Sharp Mountain, which forms its southern margin. The peculiarities of this basin, as we noticed them in the Pottsville district and as illustrated in figure 74, pursue it to the end.

FIG. 94.

SECTION AT BLACK SPRING GAP ACROSS THE DAUPHIN FORK.

Figure 94 is from R. C. Taylor's Statistics of Coal, and represents a section from the Sharp Mountain on the left, to the fourth, or Red Mountain on the right. Mr. Taylor was quite familiar with this portion of the coal-field. He spent much time, under the Dauphin & Susquehanna Coal Company, in its investigation. We differ very much from Taylor in our sections generally, simply because we have availed ourselves of late developments. He wrote at an early day, without the light we now have, and we can only express our surprise and admiration at his general correctness. In the present instance there is little to add, with the exception

of late developments in tunnelling across the basin, in which the company have discovered several seams not laid down in section 94.

We find here no deviation from the general order of the seams, except that the lower beds are split: the Buck Mountain, or B, forms two, and the Mammoth forms two, or perhaps three. But, as before mentioned, there are more seams developed since the late Mr. Taylor formed the foregoing section, and twelve seams are now proved, which will include the measures from A to G or H. But in all probability G is the highest workable seam, and is cut in the Yellow Spring tunnel at its lowest or synclinal axis, where the seam stands like a V, and is cut through its base, which is 40 feet thick. We must, therefore, conclude that, if the measures hold their average thickness, the depth of the basin is between 700 and 800 feet below the level of this tunnel.

We have before noticed the change from anthracite to bituminous coal in those fields; but no definite point has been fixed where the change commences. It has been often said that the anthracite coals depreciate in hardness from the Lehigh westward; but, though we have paid more attention to this matter than any one else, it has not appeared perceptible to us. We find the white-ash coals of the Pottsville district as hard, dense, and firm as those of the Lehigh, and there is little perceptible change this side of Swatara. We do not find the tendency to change fully developed until we reach the forks of the basin, and in these it is marked and rapid, and the western half of the Dauphin Fork is a full semi-bituminous; while the Short Mountain coals may be termed a semi-anthracite, or a grade between.

There is no comparison to be made between the eastern coals and the red-ash of the central portions of the field, because these seams do not exist at either its eastern or western end, and all the red-ash coals that may be found at these extremities belong to the lower red-ash beds,—generally A and B.

The red-ash seams produce much soft and crumbling coal, and the consequence has been that all the coals of the central portions of the field have been pronounced depreciated in hardness; while, on the contrary, the white-ash coals of the Mammoth are as hard, dense, and solid at the base of the Mine Hill as the Locust Mountain.

As a matter of interest, we may speculate on the probable breadth originally of the Southern coal-field, or how much it has been contracted. If we calculate the depth of the basins, their present angles, and probable ancient undulations, we will find in nearly all cases a contraction of nearly, if not fully, one-half: therefore, where the Southern coal-field is now 5 miles wide, it was, in all probability, originally 10 miles wide. But this rule will not hold good in any but the First coal-field generally, and the Mahanoy portion of the Middle coal-field.

CHAPTER XIII.

BROAD MOUNTAIN BASINS, ETC. ETC.

Character of the Broad Mountain Basin—Minor Rolls—Transverse Section of the Basin—Vertical Section—Mammoth Bed—Formation of Coal—Depth of Coal-Basins—Statements or Propositions in regard to the Formation of Coal—Skidmore—Gamma—Buck Mountain—The Lower Coal-Beds—Identity of the Coal-Seams—Vertical Sections compared—Tracing the Coal-Beds to the Bituminous Fields—Sullivan County Formations—Production of the First Coal-Field.

We have now briefly described and illustrated the prominent anthracite coal-fields and their principal basins; and though we have not attempted to trace their axes, since we believe it to be impracticable, we have given a concise and practical illustration of each important division and district as faithfully and correctly as present developments will admit of; and we hope our readers will find instruction and pleasure in the details.

We have not written merely for one class of readers, and have, therefore, avoided scientific and technical phrases where plain, common words would best express the meaning, so as to be understood by the general reader. We know it to be a difficult matter to explain to the unprofessional, and those not familiar with geology, the intricate and irregular formations of the anthracite coal measures, which are so much distorted and changed from their normal conditions, or the original positions in which geology teaches us they must have been formed. But when such descriptions and explanations are clothed in professional terms, and when technical and scientific names are given to local phenomena, or arbitrary specialties and nomenclatures are made use of, such accounts become unintelligible to the ordinary reader, and are only comprehensible to the professional man or the student.

The little coal-basin which we have now before us for examination is the most simple and plain and yet the most perfect of all the anthracite formations, and will justify a more than ordinary description. It illustrates, we think, the phenomena of the anthracite coal formations more fully than any other basin, and exists as nearly in its normal or original condition as any cotemporary basin of the anthracite group.

It does not properly belong to any of the grand divisions of the anthracite fields, but is a distinct and separate basin, though it connects, in a manner, the First with the Middle coal-field by the high, undulating plateau

of conglomerate, known as the Broad Mountain, which rises from beneath the Mine Hill basin, forms the Twin crests of the Broad Mountain, with the Broad Mountain basin between them, and then descends into the Mahanoy Valley beneath the coal measures of the Middle coal-field.

Owing to the nearly horizontal strata of the Broad Mountain, and perhaps its original elevation above the Schuylkill and Mahanoy Valleys, this portion of the anthracite formations has been raised by the forces which contracted and depressed the flanking or parallel valleys: consequently, its strata have not been crushed and distorted, as the measures of those low, weak, and yielding basins were. We find, therefore, much the same result in physical appearance and geological structure as in the detached Lehigh basins, which were evidently formations of a similar nature.

The tendency, however, to form the vertical by contraction from the south (though the forces might be exerted equally from the north) in the north-dipping strata is still evident, both on the Broad Mountain and the Lehigh plateaus.

There are a few rare cases where the effects of contraction are more evident in the south dips than the north; or on the north instead of the south sides of peculiar basins.

One of these is at Coalcastle, in the case of the famous "Jugular" basin or "overthrow," and another may be found in the Head Mountain basin, on the eastern terminus of the Middle coal-field, east of the Catawissa Railroad, where the south dip is nearly vertical, and the coal thick, crushed, and evidently disturbed. We do not remember another instance of this character; though it is quite possible that such exist. It is, however, a general rule throughout the anthracite regions for the north dips to assume a steeper angle than the south-dipping strata; and, as stated above, nearly all the perpendicular and inverted strata are on the south side of the basins.

We may mention here a style of basin, roll, or undulation that has merely been alluded to as existing within the principal or prominent basins, but which we have not discussed. As a critical mention may throw some light on subjects which we propose to illustrate in connection with the New Boston or Broad Mountain basin, we may here appropriately notice them.

These minor rolls or basins which we allude to generally occur on the long, gentle planes of the south-dipping strata, in which they are small undulations. They occur more frequently towards the outcrops of the coal-seams than towards the centres of their main basins; but they are occasionally found in the centre of deep basins and the steep sides of comparatively high angles of dip; but in all such cases the peculiarity which we propose to make a specialty almost entirely disappears: we allude to the *enlargement* of the coal-seams in all these minor rolls when they occur

in gently dipping strata,—say at 35° and below, but more particularly about 15°. Figure 95 will illustrate more clearly the form and character of these minor rolls.

In figure 95 we have given six illustrations of the same seam—for instance, the Primrose—on dips ranging from 5° to 50°, which represent

FIG. 95.

MINOR ROLLS, OR BASINS.

generally the form and character of those small interior or subordinate basins or undulations of the strata on the south dips, and their consequent effects on the coal-seams. We have chosen the Primrose because it is a single and regular seam, and not subject to the frequent and extraordinary enlargements of the Mammoth, yet subject, as we represent, to frequent changes and enlargements, such as affect, more or less, all the seams in the anthracite measures.

Those undulations frequently have an influence on the overlying and underlying seams, where the waves or rolls are of sufficiently great extent; but small depressions do not so much affect the overlying strata. Sedimentary deposits naturally fill the depressions faster than the elevations, and the normal condition of all sedimentary strata is an increased thickness in the synclinal and a decreased thickness in the anticlinal axes when subject to like influences: consequently, the small depressions become filled to the general horizon of the surrounding deposits.

The upper section at 5° dip in figure 95 represents some of the undulations of the Primrose above water-level in Brown's old Oak Hill colliery, where this seam makes several extensive and wave-like rolls, increasing and decreasing the dimensions of the coal from 8 to 20 feet. These extensive waves affect the Orchard, which lies about one hundred feet above, but to a less degree.

The second section illustrates nearly the undulations or rolls in the Mammoth and Primrose, on the Mammoth Vein Consolidated Coal Company's lands, between St. Clair and Wadesville, as found in the Hickory colliery, formerly operated by the Messrs. Milnes.

The third section represents a rare form of undulation, and one that happens more frequently near the outcrops of coal-seams than on their regular dips. It is found on the outcrops of the Orchard, on the Oak Hill tract, and at several other points on different seams, and is illustrated on a large scale by the undulation of the Mammoth at Wolf Creek, or the eastern point of the Jugular basin.

The fourth section, on 30° of dip, is similar to a roll or enlargement of the Primrose at the Warrenton colliery of Messrs. Miller & Maize at Silver Creek, where this seam appears to obtain its maximum size in 40 feet of thickness.

The fifth and sixth forms of undulation are sometimes met with in all the anthracite seams, and offer serious obstacles in the way of sinking "slopes." They are of very frequent occurrence in all the eastern Virginia coal-fields, as we shall notice in our description of those formations.

We find in all the foregoing minor basins an enlargement of the coal-seams; but in all *deep basins* rather a decrease than an increase of the coal. Yet the enlargement is not confined to the temporary basins on the angle of dip, or towards the outcrop of gently undulating seams: all our moderately deep or medium basins present the same feature, as in the New Boston or Broad Mountain basin, and in all the medium Lehigh basins. We therefore accept it as a fact that the coal-deposits are more uniform, and are in their maximum dimensions, when formed in basins of medium depth. We take the Broad Mountain basin as the medium, and will illustrate its form, dimensions, and character, before offering

BROAD MOUNTAIN BASIN.

it further in evidence of a theory advanced in the early chapters of this work on the formation of coal.

This is a small but uniform basin, containing the white-ash beds in their maximum dimensions and in their most perfect condition. Its extreme

length is about six miles, and its maximum breadth 2000 feet. It is 360 feet deep to the base of the Mammoth, 730 to the Buck Mountain, or B, and 860 to the lowest seam, and contains six workable coal-beds, with an aggregate thickness of 107 feet of coal.

The "Seven-feet" seam is the upper bed in this basin, and lies about 20 feet above the Mammoth, which ranges from 60 to 80 feet in thickness. Seventy-five feet below E we find D, or the Skidmore, which is 9 feet thick; and 62 feet below D we find C, which is 6 feet thick. Below these 200 feet is the Buck Mountain, or B, 18 feet thick, and in fine condition. The lower workable seam is A, 100 feet below B. A is here from 6 to 8 feet thick: a small seam exists below it, in the conglomerate, but is not considered a regular or permanent bed.

The south dips of this basin range from 30° to 35°, and the north dips about 70°. It would thus appear that even this basin has been changed from its normal condition; because we cannot conceive how sedimentary strata could form at an angle so steep as 70°. It seems to be an impossibility. However the coal may have been formed, the overlying strata must have been deposited as sediment in water. This sediment would not be deposited uniformly in basins having high angles of dip, but would accumulate much more rapidly in the bottom of the basin than on its steep sides, particularly if they dipped at an angle of 45° or over. Therefore, as we find but little difference between the thickness of the strata at right angles on steep and even inverted dips and that of the horizontal strata, we conclude that most of the anthracite basins have been contracted, depressed, or elevated, and that their angles of dip have been greatly increased. Where the strata are contorted, we almost invariably find the coal crushed and powdered; but where we do not find evidence of violent contractions, or where the coal has not been subjected to a crushing process, the seams are not injured in this respect. "Faults," however, are common in all formations; but they are less frequent in well-defined planes and in smooth and regular strata than in twisted, knotty, and rippled sediment: these irregularities are primal faults, and not the effects of subsequent causes. Coal, however, may be changed by other causes than the influences of contraction, and to the irregularities in coal formations, due to such subsequent causes as slips, "up-throws," "down-throws," "crushed strata," inverted measures, &c., we may add those caused by heat, trap dikes, and like phenomena, which have also changed the normal condition of coal by exhausting its carbon and dividing and distorting its strata. "Primal faults" are the effects of original causes. These causes we will not attempt to explain in this connection, but will offer instances and their inferences in a future chapter, under the head of "faults and irregularities:" —we allude to "rock faults," "dirt faults," "slate faults," "bottom and top rolls," &c. &c.

VERTICAL SECTION BROAD MOUNTAIN BASIN.

Figure 97 represents a section through the centre of the Broad Mountain or New Boston basin. We gave the thickness of the strata in a former page; the total depth is 860 feet; and this depth we assume as a medium basin, and the most favorable for the formation of coal, not merely because this basin presents a maximum thickness of coal-beds, but because all other basins of the same dimensions present the same favorable conditions. We may instance the eastern extremity of the Southern coal-field on the Lehigh, particularly the Summit Hill basin, most of the detached Lehigh basins, the Mahanoy basins, and the Mine Hill basins. Others might be brought in evidence; but these are enough. The original depth of those basins can only be found from the number of seams they contain, and all those in which the upper red-ash coal seams do not exist must have been originally comparatively shallow basins. Their present depth is not a safe criterion: the depth through the measures does not offer conclusive evidence of original depth, since the top of the water may have been many feet above the upper measures.

FIG. 97.

VERTICAL SECTION OF THE BROAD MOUNTAIN BASIN.

In the Pottsville basin the water-line may have been near the summit of the Sharp Mountain; and, though we have good reason to say that range was not originally as elevated as at present, it must still have been as high as the Broad Mountain at that time, since the water of the anthracite coal-fields must have had a general level, as the identical seams must have had a cotemporaneous existence. Therefore the Pottsville basin may have been more than 1000 feet deeper than the Broad Mountain,—or the difference between the level of the Mammoth and the Sandrock,—since the intervening seams were formed after the Broad Mountain basin had been filled. When or how those basins were depressed or elevated, no one can say. The contracting forces may have been gradually doing their work during the formation of coal, as we should infer; but their most violent efforts were exerted subsequently, as the crushed and inverted strata testify.

We offered a theory on the formation of coal in the early chapters of this work, and we think the formations of this basin offer abundant proof

that the commonly accepted arborescent vegetation, or the *marsh* and *bog* theories, are incorrect and erroneous, if it does not prove ours to be correct. It would be far beyond the probability, if not the possibility, for the slow growth of bog formation to form the grand column of coal represented in figure 98, or the Mammoth of this basin. According to the slow growth of bogs, as developed within the last five hundred years in Ireland and elsewhere, it would require a million years to form the magnificent bed of coal here illustrated; and according to the theory of arborescent and marsh vegetation, as advocated by Professor Rogers and others, it would not only require an equal lapse of time to produce a sufficient growth, but it would be an impossibility for any land-growth of vegetation to form a solid bench or vein of coal equal to the 12-foot *bench* of this great bed. It would require a thousand feet of massed and packed vegetation to form this 12 feet of coal; and we need not say that such a growth could not be sustained on the land or above water.

FIG. 98.

SECTION OF MAMMOTH AT NEW BOSTON, BROAD MOUNTAIN BASIN.

A vegetation capable of producing such a vast mass of coal must not only have taken root in the depth of the basin, and grown up through it, but the successive growths of years must have accumulated and settled in it. We have no doubt that the increase of growth was on the surface of the water, but that yearly increase receded beneath the water and formed the mass, which could not increase in any other manner from simple vegetation. But, as before stated, we do not credit the theory of the formation of coal from vegetation alone. The carbon oils, which at that day must have been in excess, particularly in the coal formations, were perhaps the most active agent in preserving the vegetation and in increasing and cementing its bulk, as set forth at large in the early chapters.

That petroleum forms bitumen by evaporation and sediment, requires no proof here; it is a fixed and commonly accepted fact; and that this oil was the product of this era and existed in profusion, the immense bituminous deposits testify: therefore, it is natural that the resulting bitumen should unite with the vegetation to form coal, since both must have resulted in the same basins and could not escape contact. It is not only

the most natural process that can be suggested, but it is the only one that can be reconciled to all the conditions of our coal formations.

The interruptions to the continuous growth or formation of coal are frequent even in a single bed, and it is rare to find more than 5 or 6 feet of a solid *bench* that is not intercalated with slate or some evidence of a check or interruption to the continuous accumulation of the bed. In figure 98 we find one bed of 12 feet, and in other beds illustrated we have given nearly equal benches; but these are streaked with horizontal divisions or layers, giving evidence of depression and change,—perhaps marking the periods of subsidence beneath the surface of the water.

There are seven principal interruptions or divisions in the Mammoth at New Boston, marking the eras of complete submergence, if not precipitation, since the strata of slate indicate an interruption to the formation of coal, and a deposit of argillaceous or arenaceous matter. In this respect, the Mammoth is made up of seven distinct seams; but these dividing slates are not only liable to change, to increase or decrease, in the same basin, and at short intervals, but they do not appear in the same character in other basins.

From evidences accumulated from various sources, and the facts developed by our examination of the anthracite and bituminous coal formations in this country especially, we conclude:—

1. That basins of 1000 feet are the best and most favorable condition for the growth or formation of coal, and that the largest beds are formed at a depth of from 200 to 500 feet from the surface.

2. That the coal measures were originally formed in gently undulating basins filled with water, and that their normal condition has been changed in all cases of high angles and inverted dips by contraction of the earth's crust, and the consequent elevation and depression of the axes.

3. That coal was formed in water by the accumulation of carbon and bitumen, from an excessive growth of vegetation and the condensation resulting from the evaporation of carbon oils, which were produced in profusion in the same basins in which the magnificent vegetation of the coal era flourished; and, consequently the contact and result could not be avoided.

4. The extraordinary growth or formation of coal in the anthracite regions is due to an excess of naphtha or petroleum, which resulted from superior heat due to volcanic influences; and the nature of the coal is also due to the same causes.

We have thus tersely stated propositions which we believe may be called *facts*, and which we think will stand the critical investigations of the practical. Merely scientific inductions have had no influence in forming these conclusions; and we do not think that any but the practical, who are familiar with existing facts, can properly appreciate a subject so abstruse and obscure.

We have faithfully tried to elucidate the propositions at large in another part of the work, and only briefly allude to them here in connection with the coal-beds, to bring the subject in bolder relief before the mind. But those who would understand us clearly, and who wish to gain a comprehensive knowledge of this part of our subject, should read Chapter IV.

FIG. 99.

SECTION OF D, OR SKIDMORE, AT NEW BOSTON.

The Skidmore at New Boston, in the Broad Mountain basin, is not in as perfect condition as the Mammoth. It is, however, as good as this seam is generally found, and better than its usual condition in the Southern coal-field. The amount of good coal is over 6 feet, while that represented by white lines in this case is bone, which is not always a serious objection, except when the *bone* is not streaked in the benches of coal. A mass of hard bone or slate between the benches can always be removed and prevented from mingling with the prepared coal. But when thin streaks of bone or slate are intercalated in and through the solid benches, it becomes impossible to separate them from the prepared or marketable coal.

The thickness of D is 9 feet in this basin, which is over its average thickness, but less than its maximum thickness in the Mahanoy and Lehigh basins.

FIG. 100.

SECTION OF C, OR GAMMA, AT NEW BOSTON, IN THE BROAD MOUNTAIN BASIN.

C is not often in a workable condition, and seldom as pure as we find it here, with nearly 7 feet of merchantable coal, divided by two small bone partings. In the Black Creek basins of the Lehigh group it is rather larger, but in the Beaver Meadow basin it has not been developed.

The Buck Mountain bed, or B, of our nomenclature, though not in its maximum dimensions, is here in its best condition. It is almost a solid bed of coal, 18 feet thick, with a few unimportant streaks of bone and slate. In this respect it does not much resemble its celebrated counterpart of the Buck Mountain, which is divided by a massive slate, and which is a distinguishing feature of this bed wherever found, within our experience, except in this single locality. There cannot, however, be any mistake in regard to the identity of the bed, since in every other respect it is a perfect counterpart. The absence of slate in this coal is not more remarkable than its absence in the Mammoth above it, and can only be attributed to the general and extraordinary purity of the coals of this basin.

The lower seam A we have not made the subject of special inquiry, but we understand it is here in workable condition, and from 6 to 8 feet in thickness,—which is its maximum size.

The Broad Mountain coal formation extends westward of the New Boston basin; but hitherto no coal has been developed in a workable condition, though we have reason to believe it exists.

Fig. 101.

SECTION 8, OR BUCK MOUNTAIN, IN THE NEW BOSTON OR BROAD MOUNTAIN BASIN.

THE LOWER COAL-BEDS.

The existence of workable beds beneath the Mammoth and Skidmore has been denied by some of our prominent engineers, and but little is known concerning them by the miners of Schuylkill. It is unsafe, however, to conclude on general formations from local causes and evidences. Those simply familiar with the formations east of the Mine Hill might readily come to such a conclusion; but a general knowledge of the anthracite measures must convince any practical man, despite his prejudices to the contrary. But though the seams do not assume their best condition in the Schuylkill district, they are still uniformly in place, as our section, figure 76, satisfactorily proves; while our sections of each seam prove conclusively their existence in the Schuylkill district, and figure 71 shows a similar formation at Tamaqua. There is a general and constantly varying difference in the thickness of both the coal-seams and the intervening strata; and, in order to show parallel formations, we have given the thickness respectively in figures, rather than form the sections to a uniform scale.

For instance, the section at Scranton, figure 25, containing all the seams below J, is only 455 feet in vertical height; while the column at Pottsville below J, or the Diamond, is over 1000 feet; but we have made them about the same dimensions, in order to justify the beds, or bring the Mammoth as a base-line on the same horizon, and we thus offer to the mind and the eye both the identity and the relative distances and dimensions.

The figures we have given are not generally the results of actual measurements: whenever available, we have given the exact distances, but more frequently they are approximate measurements, yet near enough to the truth for all practical purposes.

We give a parallel representation of the columns from each of the principal coal-regions, in order to exhibit the general uniformity and order in which the workable or prominent seams are stratified, and to prove more conclusively this identity. It brings before the eye, in a comprehensive manner, the formation or measures of each district, and the order in which the beds are stratified.

The twelve foregoing sections exhibit more uniformity and order in the

FIG. 76.

FIG. 71.

FIG. 97.

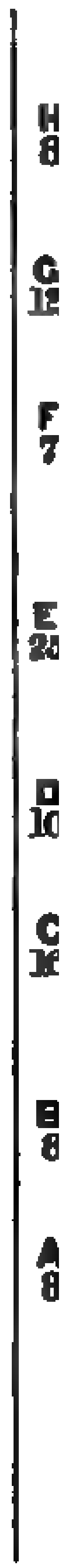
FIG. 49.

POTTSVILLE. TAMAQUA. NEW BOSTON. BLACK CREEK

Fig. 59.

Fig. 62.

Fig. 55.



SHAMOKIN. LOCUSTDALE MAHANOY. NEW BOSTON.

FIG. 36.

FIG. 25.

FIG. 115.

FIG. 45.

WILKESBARRE. SCRANTON. HAZLETON. SULLIVAN COUNTY, PA.

anthracite formations of Pennsylvania than we had anticipated in the commencement of this work: we were not prepared to find so much consistency or so complete an identity in the respective seams, though we have been practically familiar with the anthracite coal measures for thirty years; and we presume our practical readers will be surprised to find so much order and conformity, when local formations present so many changes and frequently so much confusion.

We have not, however, formed the sections at faulty or disturbed localities, but have invariably sought our data at points where the measures were regular and consistent.

Sections might be formed from actual developments at the Lehigh terminus of the first coal-field, at Coalcastle in the Mine Hill basin, at Mahanoy City, at Shenandoah City, at Pittston, and many other places, which could not be recognized as belonging to the same coal measures. But these are irregular formations, and cannot be taken as types even of the district in which they exist. Figure 115 is a vertical section of the Sullivan county (Pennsylvania) semi-bituminous basin, which represents a point between the anthracite and bituminous fields. It is the most eastern of the Alleghany formations, and, in a manner, connects the two. The Broad Top coal does not belong to the Alleghany field, and is more in connection with the anthracite than the bituminous fields, as far as geological affinities affect them.

COAL-TRADE OF THE FIRST, OR SOUTHERN, ANTHRACITE COAL-FIELD, FOR 1864.

Lehigh District.

Duglas, Skeer & Co., Room Run Mines	86,700
Lehigh Coal & Navigation Company, Old Summit Mines	347,980
E. Jeffries & Co	12,031
Lehigh Coal Company	25,124
	471,844

Tamaqua District.

Greenwood Coal Company	56,374
George W. Cole	87,033
Moss, Wood & Co., on Lehigh Coal & Navigation Company's lands	34,685
Ratcliffe & Rollston	22,378
Johnson & Ormrod	19,456
George Brown	12,123
Little Schuylkill Company	4,781
	187,010

Pottsville or Middle Districts.

Heckscher & Co. (including H. H. Dunn, agent, 46,921)...	207,903
Geo. S. Repplier................	80,347
Geo. H. Potts....................	78,795
Mammoth Vein Consolidated Coal Company................	145,345
A. C. Miller & Co...............	37,838
Wm. H. Johns..................	84,558
Wm. Kear & Co................	82,841
St. Clair Coal Company........	67,476
Geo. W. Snyder.................	66,561
Swatara Falls Coal Company.	63,923
Wm. H. Starr...................	63,831
Wm. Hindman.................	45,317
Phœnix Coal Company........	42,580
C. Garretson.....................	23,891
Kirk & Baum....................	34,830
J. H. Bracken	28,780
H. W. Fuller	28,101
B. Hammet......................	27,022
Glen Carbon Coal Company..	25,535
H. Guiterman....................	24,918
J. A. Dutter & Co.	23,157
W. R. Williams.................	20,725
Kaska. William Coal Co......	20,482
Beddall & Robinson	20,114
C. Frantz........................	19,750
Norwegian Coal Company.....	19,664
R. Lockart & Co................	19,286
	1,403,565
Brought forward,	1,403,565
Duncan Coal Company..........	18,945
Pottsville Mining and Manufacturing Company...........	18,152
Consumers' Mutual Coal Co....	17,961
J. S. Serril........................	17,290
John Dougherty..................	17,108
Charles Saylor...................	16,293
Allan Fisher......................	16,105
John Ralston.....................	15,417
Goodman Dolbin.................	15,414
R. Winlack & Co................	11,666
J. Buckley & Co.................	11,230
East Mountain Laffee Coal Co.	9,643
Gilfillan & Ganley..............	9,243
Wm. Dovey	8,720
Richards & Fisher..............	5,322
Wm. Spencer, agent............	4,745
Wm. Littlehales.................	4,400
Wells & Smith...................	3,942
Silliman & Foster...............	3,785
D. Whitehouse...................	3,027
W. N. Taylor & Co..............	3,026
J. Sheard	2,991
Potts & Snyder (new)..........	2,956
Broad Mountain Coal Co........	2,917
Wm. L. Williams................	2,789
Job Rich..........................	2,220
Sundry small shippers..........	28,987
	1,677,557

Pine Grove District.

Henry Hiel..	32,844
Wheeler, Miller & Co...	19,591
Eckert & Co	13,125
Ettien & Lomison..	5,465
Red Mountain Coal Company (new)............................	232
Kitzmiller, Graef & Co..	144,784
	17,041

Lykens Valley District.

Lykens Valley Coal Company	consolidated	 68,021
Short Mountain Coal Company		.... 61.952
		129,073

Dauphin District.

Dauphin & Susquehanna Coal Company	146,669

Recapitulation.

Lehigh, or Eastern District	471,844
Tamaqua District	187,010
Pottsville or Middle Districts	1,677,557
Pine Grove District	217,041
Lykens Valley District	129.973
Dauphin District	146,669
Total from First Coal-Field	2,920,094

CHAPTER XIV.

FAULTS, IRREGULARITIES, AND PECULIARITIES IN COAL FORMATIONS.

General Form of the Eastern Strata—Depression and Contraction—The Pottsville Section, figure 74—The Jugular Inverted Basin, figure 75—Shenandoah City, figure 54—Wiconisco, figure 93—Diamond Mines at Hazleton, figure 102—Faults—Trap Dikes—English Faults—Slip Dikes—Change of Horizon—Saddles, or Horse-Backs—"Troubles"—Richmond Coal-Field—Rock Faults—Slate Faults—Dirt Faults—Black Dirt or Outcrops.

WE do not propose to confine ourselves exclusively in this chapter to the anthracite coal measures; but, as most of our illustrations have especial reference thereto, and as most of our subjects will be in connection with the anthracite formations, we continue the chapter under the head of the anthracite coal-fields.

We have never seen our present subject illustrated or treated in books; and perhaps it is less understood than any other phenomena or peculiarity in the lithological structure of the earth. There are many irregularities and apparent contradictions in geology, of which we shall not treat, as our special attention is directed to the coal measures, and more particularly those of the anthracite formations; but we find in the details before us a miniature of the general peculiarities of the earth's crust.

GENERAL FORM OF THE EASTERN PALÆOZOIC STRATA.

We must here briefly notice the general configuration of the Palæozoic strata on the Atlantic slopes, in order to present clearly the contraction and foliation of the coal-strata, in conformity with the formations in which they exist, and which will be found more extensively treated in Chapter III.

Most of the north-dipping strata in the Blue Ridge and parallel mountain-ranges are either vertical or inverted, as shown in figure 74, in the south basins of the anthracite measures, exhibiting this peculiarity from the great mountain-chains down to the mere roll in the coal measures. In the anthracite regions, this system of inverted or elevated strata is more marked and peculiar north of the Great Valley limestone formation than south of it; but farther south, in the mountains of Virginia and North Carolina, it embraces a wider range, and extends from the gneissic rocks to the coal measures of the Alleghanies. But there, as here, the undulations are more acute to the east than the west. On the New River, in Montgomery and Pulaski counties in Virginia, as will be shown in our descrip-

tion of the New River coal-field, the north-dipping strata are inverted as much as they are at Pottsville, and at many intervening points the same inverted feature is manifest, clearly demonstrating the fact that the deep inverted basins increase to the east and diminish to the west, along the entire Appalachian chain of the Atlantic slopes from north to south. Figure 74, or the transverse section of the coal-basins from the Sharp Mountain to the Mine Hill in the vicinity of Pottsville, is a miniature section of the foliation from the Blue Ridge to the Alleghanies, and exhibits generally the progressive increase in the dip of the strata from west to east.

As stated in Chapter III., this peculiar feature of the eastern formations is due first to volcanic influences, and secondly to the forces of contraction. Volcanic vents on the long line of granite coasts first caused a subsidence or depression of the eastern marginal depth of the ancient Appalachian Sea (now containing the Palæozoic strata from the Blue Ridge to the Rocky Mountains), and formed the base or synclinal axis of the deep Southern basins; and subsequently the forces exerted by the contraction of the exterior portions of the earth's crust crushed those basins together in a lateral manner, as shown by figure 6 and explained in that connection.

We can readily comprehend that the sharp axes of highly inclining strata would be the weakest point under those lateral forces, on the same principle that a book folds or hinges on its back; and since those weak points existed on the long line of sea-coast, or volcanic shores, from one end of the Appalachian chain to the other, they now constitute our inverted axes of formation, and disclose the fact that the contractions of the entire Appalachian basin, from the Blue Ridge to the Rocky Mountains, were concentrated here, or along the weakest line of the crust-formations.

In figure 74, as above stated, will be found a miniature representation of this general contraction, and the features of the foliation as it decreases from east to west; and in the local illustrations will be found simple repetitions in miniature of figure 74. These irregularities, therefore, become the rule instead of the exception, and constitute a vast system of highly foliated strata,—doubled almost as acutely as the folds of a map or a handkerchief, and frequently inverted or leaning to the "wrong side" of the axis.

Figure 75, illustrating the "Jugular" formation at Coalcastle, is perhaps as correct a representation as could be given of this inverted feature in our geological formations. We can only account for it on the principle which we have advanced as governing and controlling all such formations, and as many of our practical geologists account for similar foliations in the Alps and elsewhere.

We have illustrated this feature of the anthracite coal measures pretty

fully from local formations. Figure 54 represents two inverted basins at Shenandoah City, in the Mahanoy coal region. The engraving does not fully show the basins, but both north and south dips appear as south dips in the same basin. Figure 93 is a representation of foliated strata at Wiconisco, in the western end of the Lykens Valley fork of the First, or Southern, coal-field. It exhibits a new feature, not entirely peculiar, but one that is rarely developed in the coal measures. The inverted strata are here developed in reverse order, and the whole formation, including the conglomerate, is shown to be elevated instead of depressed, but bent and distorted, evincing the effects of lateral contraction in the most positive manner, since no other force could produce the same effects.

In other portions of this work we have made frequent allusions to these inverted formations, particularly in reference to the "Jugular overthrow" at Coalcastle, and promised to explain them fully. We think this promise has been fulfilled in connection with the illustrations as they appear in order, and the present reference to the same.

The engravings, however, explain themselves to the practical mind, and convey a better impression of the subject than can be obtained from the text, however carefully worded, without their assistance.

If we have stated the facts clearly, there can be no doubt left in regard to the mythical character of the great Jugular humbug; and not only will that matter be settled, but all inverted dips and irregular formations in the anthracite coal measures may be accounted for and understood on the same general principle.

CONTRACTION AT HAZLETON.

One of the most singular instances of inversion of strata, or the effects of contraction, is found at the bottom of the Diamond mines, Hazleton. The Hazleton basin contains an anticlinal running through its centre, and,

Fig. 102.

DIAMOND MINES, HAZLETON.

at the western end, at least two of these axes. At the Diamond mines, near the town of Hazleton, this middle axis is inverted, as shown in figure 102. The "Big Vein" is folded back over the north dip, so that the *bottom slate* of the first north dip becomes the *top slate* of the second north dip (really a south dip of the central axis), but passing over the sharp,

inverted point of the axis or saddle, the second true north dip assumes its proper position and condition. This sharp folding of the strata in the Hazleton basin takes place at a depth of 900 feet vertical, where the breadth of the basin is 2600 feet between the outcrops of the Mammoth, and where the general dip of the measures is between 35° and 40°.

It is very evident that such could not have been the normal condition of the bed, since no sedimentary strata could have been formed in this inverted manner. It must, therefore, have resulted from subsequent causes; and since we can find no cause so probable as the natural and irresistible forces of contraction, we conclude such to have been the power which has contorted and crushed not only the anthracite coal measures, but the long, parallel waves of inverted strata in which these measures exist, from the Blue Ridge to the Alleghanies.

Though the instance we have given in figure 102 is peculiar, it is not entirely singular; other instances of the same kind may be given; but we have selected the various forms of contracted strata in order to illustrate the subject fully, and as shown in our numerous sections.

Figure 70, representing this peculiarity in the Tamaqua Shaft colliery, is the nearest approach that we have given to the inversion displayed in figure 102.

FAULTS.

This is a local and technical name given to the faulty and imperfect portions of the anthracite coal-beds of Pennsylvania, as "troubles," "hitches," "dikes," "horsebacks," and other technical phrases are locally used to denote impurities and irregularities in the coal-seams of other regions and countries.

The faults existing in the anthracite regions are peculiar to these formations, or to the long line of inverted and folded strata which occupy our Eastern Palæozoic coast-range. In the anthracite fields faults are both numerous and variable; but they are not extensive, and never occupy any

Fig. 103.

TRAP DIKES—ENGLISH COAL-FIELDS.

great area in any given locality. The only great and regularly-disturbed portion is the inverted and crushed strata of the Sharp Mountain coal measures; but even there a considerable portion of the coal is merchantable.

The chief defect is the crushed and shelly condition of the coal, which is subject, in consequence, to much waste.

TRAP DIKES.

Figure 103 represents the general form and effects of the English trap-dike faults, which consist of lava ejected or forced from the molten bowels of the earth through its confining crust by the forces of *contraction.*

The cooling and contracting process which the rocky crust of the earth has undergone, or is undergoing, on its molten and uncontracting core, naturally produces that irresistible effort to escape which we see exemplified in dikes, volcanoes, &c. In England, where no great volcanic peaks exist, and where the formations are uniform, and, consequently, without those peculiar weak points which yield to the forces of contraction, the condensed lava bursts through the confining crust in long lines of trap, which are known as trap dikes. In the English coal measures the dikes thus formed by the lava are frequent. They occupy long parallel lines across the coal measures and through the adjoining country,—often from sea to sea. These trap dikes burst through the strata nearly at right angles, but sometimes lean with the line of "cleavage." The coal-seams are cut and divided by the lava, and frequently one portion is carried upwards by the lifting power of the molten mass until the connecting points are several hundred feet "out of place," as in the instance of the "90-fathom dike" of the Newcastle coal-field.

Thus the forces of contraction are exerted according to the geological character of the country or district in which they occur. In Mexico and other volcanic countries the lava escapes through volcanic vents, as the earth's crust contracts until its rocky bands are forced to yield to that power which nothing can resist. In Chapter IV. we stated an instance of the terrible force with which volcanic lava is vented. It is said that Cotopaxi, which is nearly 19,000 feet high, has projected lava 6000 feet above its summit, and that it once threw a stone 109 cubic yards in volume to a distance of nine miles.

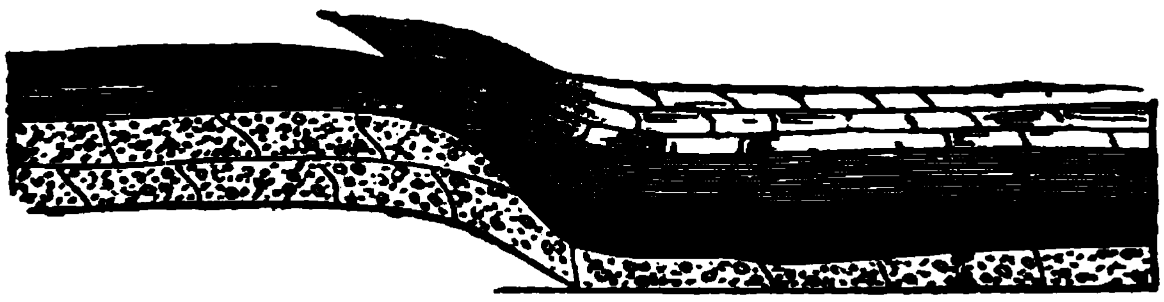
In the United States we find the forces of contraction east of the Rocky Mountains exerted on the foliated and yielding strata of the Atlantic slopes; while west of the Rocky Mountains we find it vented in volcanic eruptions, and in England we find the trap dikes. We allude to the exertion of those forces, in these instances, however, since the formation of coal: prior to that period, volcanic eruptions were general in all sections.

SLIP DIKES.

The *faults* of the English coal-seams, therefore, are quite different in form and character from those which are peculiar to our anthracite

beds. There the chief or predominating feature of *faults* in coal is that of trap dikes and "slip dikes," which affect the seams extensively and seriously by "lifting" or changing the horizons of the strata above their proper connections. Thus, we find in the Newcastle district a great many faults of this character, where the seams are disconnected or lifted one above the other, as shown in figure 104, which, however, was not designed to illustrate the English "slip dikes," but rather the local slips in the anthracite fields. It represents, notwithstanding, the English crust-movements or slip dikes,—the result of the trap dikes or their causes.

FIG. 104.



SLIP DIKE.

There is a slight error in the mechanical execution of the above illustration: the oblique line of the slip should cross the measures or pass down through the bottom in the same manner as the top; and the slate shown under the upper portion of the seam should also be shown under the lower portion: otherwise, this figure represents correctly the English slip dikes. But there those slips, like the trap dikes, affect the measures throughout; while here the slips, as shown in figure 104, are simply local, and may or may not affect the seams above and below. They are simply moved from their original position by the lateral movements of the crust, instead of the vertical, as in the British coal-fields. The coal in the anthracite fields, when moved by slips, is not materially injured, except by the crushing process, which simply crumbles it. But in the English coal-fields, in the vicinity of the trap dikes, the coal is generally either burned to a cinder or completely coked; in the vicinity of the slip dikes, however, the coal is simply moved from its normal condition or parted in a nearly perpendicular manner.

There are exceptions in the trap-dike faults, however, where the coal is not injured by heat; but in those cases there is evidence of the formation of the dike prior to the formation of the coal, and the coal is deposited on the inclining sides of those dikes at a less angle than where they have been of subsequent occurrence.

CHANGE OF HORIZON.

Figure 105 represents another class of faults found in all coal-fields, but to a greater extent in beds which have been forced from their normal

condition than where the original conditions exist. For instance, a lower bed may be moved from its horizon by contraction or volcanic causes,

FIG. 105.

CHANGE OF HORIZON.

and form an uneven horizon of strata; the consequence is that the overlying strata would conform, in a measure, to its moulding influences; or the deposited sedimentary strata may be swept away by currents and shifted from point to point, thus forming their arenaceous beds much thicker at one locality than another, even in coal-fields which have not been changed from their normal conditions, such as our Western coal-fields generally.

The tendency in faults of this character is to depreciate the coal in character and extent; but they do not generally exert their influence to any great extent on the overlying seams.

As represented in the engraving, the deposits of slates are thicker on the lower than on the upper portions of the coal, and, consequently, the natural tendency would be to return to the uniform horizon of formation, which can only be changed, as before stated, by violence or some irregular process.

"SADDLES," OR "HORSEBACKS."

Figure 106 is another form of fault, arising from the causes explained in connection with the preceding figure. It is an expiring anticlinal,

FIG. 106.

SADDLE, OR "HORSEBACK."

which may have been of much greater extent at a greater depth. Faults of this character are known generally as "horsebacks," and "troubles." They are, like the foregoing, frequent in all coal formations, and, we presume, result from the same causes. Sometimes they are extensive, and tunnels are required to be cut through rock hundreds of feet to connect the seams; and it is a difficult matter to tell whether the faults are simply

changes of horizon, or horsebacks, and proof is necessary, by following the seam, before the permanent workings can be continued. Horsebacks, however, are not so troublesome to the miner as an extensive change of horizon: in the former case a tunnel will connect the plane of the coal, but in the latter inclines must be used in flat seams; in pitching seams a simple change of the course of the "gangway" or heading will obviate the difficulty. If an up-throw, the course changes towards the top of the seam; if a down-throw, it changes towards the bottom.

In the nearly horizontal coal-fields of the West, these rolls or horsebacks are frequent, but generally more gentle in angle, though more extensive in scope, than the one represented. They exist also in an inverted position, or they form bellies, or "swellies," in the coal-strata, instead of horsebacks or saddles. These faults—if faults they may be called—or irregularities are more troublesome to the miners than the former, because in the first the coal can be obtained without trouble in contending with water, but in the latter it cannot, since a basin instead of a saddle is formed.

"TROUBLES."

Figure 107 belongs to the class of irregularities illustrated in 105 and 106, but is the result of quite a different process, and is peculiar to granitic

Fig. 107.

"TROUBLE"—VOLCANIC FORMATIONS.

or volcanic formations. In the Richmond coal-field an anticlinal axis is known as a trouble; but there these axes are local and occupy short lines, or are anticlinal cones instead of anticlinal ridges.

The illustration we give in figure 107 is from the Richmond (Virginia) coal-field, where such formations are frequent, as shown in the sections accompanying our description of that field. There is not much evidence of contraction or subsequent crust-movement in the Richmond coal measures, but the unequal and irregular granite base upon which those measures were deposited influences the strata to a great extent. Though the basins are frequently over a thousand feet deep, the granite peaks project through the measures, and often appear at the surface. Generally, however, they are of less elevation; but their frequent occurrence seriously interferes with mining operations. We have known several instances in

which deep and costly shafts have been sunk on the crown or apex of one of those "troubles," and which were, consequently, unavailable. It is a very difficult matter for inexperienced men, or, in fact, miners generally, to locate properly in this field on unexplored lands. But an anticlinal always shows its dip at some distance from its axis; and the prudent will seek such evidence before risking years of labor and large outlays of money.

We find the coal in those deep Richmond basins increasing in thickness towards the synclinal axis, or both the sedimentary deposits of arenaceous and argillaceous strata and the coal are thicker in the basins than on the dips, while on the troubles or anticlinals there is scarcely a sign of coal, and the measures are correspondingly thin. The inference, therefore, is that the present is their original and normal condition, and that the coal was deposited as it now remains.

It is natural to suppose that sedimentary deposits should tend to the deepest parts of a basin; and here we find it exemplified. Were the present form of the anthracite basins their original or normal condition, we might expect to find nearly all our coal in the deep basins; but, as such is not the case, we find the best and most productive seams in moderate or medium basins, rather than in the deepest.

ROCK FAULTS.

Figure 108 illustrates a fault frequently met in all coal-fields, and one common to the anthracite regions. It consists of a stratum of slate or rock rising from the bottom and ascending diagonally across the coal to the top, or *vice versâ*. This is a troublesome character of fault, since it is difficult to determine whether it is a change of horizon or an "off-throw." When it comes in from the bottom and goes out at the top, the seam is below; but when it comes in from the top and goes out at the bottom, the seam is above. In the first case the miner digs down through the rock or slate to the coal, and in the latter he digs up. The dimensions of these faults are various, ranging from a few inches to several yards, but they are never very extensive; though it frequently happens that hundreds of feet are driven through them in search of the missing seam, when it lies but a few yards off in a parallel course.

FIG. 108.

ROCK FAULT—THROWING OFF THE SEAM.

The causes of these faults are rather obscure, but they evidently resulted from some commotion, current, or force, which interrupted the regular course in the formation of coal, and deposited or conveyed an extra portion of sedimentary strata to such localities. An explanation of figure 109 may convey an impression of this process.

Figure 109 represents a frequent occurrence in the anthracite coal measures, and one which is peculiar to nearly all coal-seams. It consists of the enlargement of a slate parting, which may or may not belong naturally to the seam; but it generally springs from a natural parting, perhaps scarcely perceptible at first, but gradually increasing in thickness

FIG. 109.

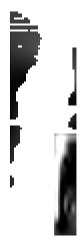
ROCK FAULT, OR DIVISION OF SEAM.

until the seam becomes parted beyond the point where it can be worked profitably as a single bed. In the anthracite regions these slate or rock partings grow from east to west: for instance, the Buck Mountain seam is thus divided by slate, which increases in thickness from east to west, until it forms two distinct beds; and the Mammoth is likewise divided into three large and separate seams in the same manner.

This, we think, is easily accounted for. Though the aggregate thickness of the sedimentary strata is greater in the east than in the west, the corresponding thickness of the coal is much greater. The causes producing coal were more active and constant in the east than in the west: while the great Mammoth of 30 and 50 feet was in process of formation in the deep eastern basins, the growth or formation of coal was interrupted in the western portions, and sedimentary strata took its place for a season, or until the process could be restored. As a general rule, we find both the seams of coal and the coal measures depreciating in a westward course, while the beds are frequently split; and one which may be very thick in the east may form two or three, which may be very thin, in the west. But there are also local cases of this form of division or splitting of the seams, originating, generally, from some band or stratum of slate which naturally exists in the bed. These slate bands occasionally enlarge and form a double bed from a single one; they also contract and form a single bed from a double one, if we simply trace them from localities; but if we follow the horizon of such double beds, we find them constantly changing and varying in their distance from each other. The cause can only be accounted for from the fact that the growth of coal is more limited in one

locality than another, and that the sedimentary deposits are much thicker at one point than at another. As explained fully in Chapters III. and IV., we believe the sedimentary strata of the Palæozoic formations to have been derived chiefly from volcanic influences. The lava of volcanoes on being thrown in a molten state into the waters is instantly shivered to atoms, and either thrown into the air in the shape of ashes and sand, to be carried by winds to remote parts, or is disseminated through the waters, and carried by constantly changing currents to as constantly varying localities.

FIG. 110.



ROCK FAULTS.

We represent in figure 110 three frequent forms of "rock faults," which, as far as our experience goes, are found in all coal-fields. They consist of narrow walls of rock, which cut the seam either perpendicularly or obliquely, and are from one foot to several yards in thickness. We find them extending from one seam to another through the measures, but generally only a short distance above or below the coal. They are like small trap dikes, but are invariably a coarse sandstone, having no appearance of igneous origin, and consequently must have been the result of sedimentary deposit, in the same manner and at the same time with the stratified sandstones of the coal measures. But how these isolated, narrow, and singular walls of rock were laid in long lines through the coal-seams cannot be satisfactorily explained.

SLATE FAULTS.

Slate faults, as represented in figure 111, frequently occur in the Pennsylvania anthracite seams, and sometimes in the bituminous coal-fields of

FIG. 111.

SLATE FAULT.

the West. We have also found them in the Richmond and New River coal-fields in Virginia and elsewhere. They appear to be normal formations, or interruptions to the growth of coal in its original formation, and

may be accounted for in the same manner as we would account for the increase or enlargement of the slaty partings in coal-seams, which are sometimes only an inch in thickness, but are often found in a few miles to have increased to several feet; in fact, these dividing slates vary from an inch to 40 feet.

The deposit of slate which we represent as a "slate fault" differs, however, from slate partings, which are natural and to a certain extent regular. *Slate faults* are interruptions, and frequently occupy the entire seams; but generally only a portion of the seam is occupied by the slate. The extent of these faults is variable,—sometimes only a few yards in extent, but as often several acres. We must consider them local interruptions to the coal growth or formation.

DIRT OR SOFT FAULTS.

There is not much difference between the slate fault and the *dirt fault*. They are both organic defects, and not the results of any subsequent action. The dirt faults are generally more extensive than the slate faults, and are almost exclusively confined in the anthracite regions to the red-ash seams,

FIG. 112.

DIRT FAULT.

and differ from the *crushed faults*—resulting from the forces of lateral contraction—in containing no available coal. These faults generally "come in" on the top, and gradually increase until all or most of the *coal* disappears, and go out on top in the same manner, with an enlargement of the coal as the *fault* disappears.

The character of this fault is, however, variable, and its forms are changeable. In place of the coal we find a soft, carbonaceous dirt, of a plumbageous or graphitic appearance, mixed with slate or shelly coal,—always one or the other. Some faults appear as if their carbon had escaped, as we find displayed in the outcrop of coal-seams,—the "bloom" or black dirt of which, though a part of the bed or seam, contains no coal, until confined and covered by a considerable body of overlying strata, when the coal dirt changes to coal by a gradual hardening. In other "dirt faults," where the slaty principle predominates, we would assign a different cause, much the same as that mentioned in connection with the preceding slate fault, but with this difference:—in the slate faults the formation or growth of coal is interrupted to the extent of the fault; but in the dirt fault the

growth is only checked and partial, and mixed with impurities, caused by currents, eddies, or some commotion of the waters in which it was formed.

With these remarks, we must close for the present this short chapter on faults. The subject demands more elaborate treatment, and would form an interesting subject for a volume; but time and space admonish brevity, and we can only promise to return to the subject on some other occasion, if opportunity offer.

PART IV.

CHAPTER XV.

WESTERN BITUMINOUS COAL-FIELDS.

Broad Top Coal-Field—Its Geological Position and Character—Vertical Section of the Broad Top Measures—Identification of the Coal-Beds—The Buck Mountain—Mammoth —The Mahoning Sandstone—Pittsburg Bed—Freeport Beds—Freeport Limestone—Feriferous Limestone—Iron-Ores of the Coal-Fields—Extent and Identity—Geological and Topographical Position of Broad Top, and Extent of the Coal-Field—Railroad Connections—Coal-Seams—Analysis of Coal—Shipments of Coal—Names of Firms and Coal-Operators—Mining Coal and Ventilating Mines—Iron Ores—Coke, &c.

BROAD TOP COAL-FIELD.

WE propose to include this small coal-field with the bituminous rather than the anthracite formations, though it occupies a place between the two, and, strictly speaking, is an independent field, belonging to neither the one nor the other, and is a peculiar semi-bituminous coal-field. Its coal is lustrous in appearance, like the anthracite, but square-fractured, like the bituminous: its place in our geology identifies it more nearly with the Western formations than with the anthracite. But, however we assign it, both bituminous and anthracite belong to the great Appalachian basin, and were the formations of the same era, the results of the same causes, and found in much the same conditions.

The Broad Top coal-field* is limited in area, but the accompanying vertical section demonstrates the amount of coal it contains to be in excess of the same area in any other outlying basin of the great bituminous formation. It contains four workable seams of fair dimensions,—larger, in fact, than the general size of the bituminous seams in other regions.

We fail to find, however, the "Big vein" of Cumberland and the Mammoth of the anthracites; but the place it should occupy is filled by *two seams*, evidently synonymous with the Mammoth, which, as before observed, splits in its westward course. We think the coal presented in figure 113 is identical with the white-ash coal of the anthracite fields.

* We have changed the position of this coal-field from the map furnished us by the Broad Top Railroad Company,—placing it as nearly north before the reader as possible.

In this section we find no difficulty in tracing a parallel with the sections

given in connection with the anthracites, or of identifying the seams,

Fig. 113.

though we have named them, perhaps, differently. A is undoubtedly the counterpart of that given on or near the conglomerate as the bottom seam in the anthracite regions. B we cannot fail to recognize as the Buck Mountain bed; while the next overlying seam, which is only one foot thick, must be C, or Gamma, of our nomenclature. It is always a small seam, seldom workable, and often, even in the anthracite regions, as thin as it is here.

C, in figure 113, occupies the place of D, and is really the Skidmore. The seams marked D and E are undoubtedly the Mammoth; while the small intermediate seams may be splits of the same, or leaders, which we often find in the same ground in the anthracite regions.

The small seam, F, above the Mahoning sandstone—which is here 25 feet thick, and which is identical with the massive sandrock always found between E and F—is identical with the "Holmes." It overlies the Mammoth everywhere in connection with the great sandrock, known in the West as the *Mahoning sandstone*, and is the only regular seam to be found in the "barren measures." It is always small, seldom exceeding four feet in the anthracite regions, and not often over twelve inches in the bituminous fields. It overlies the great bed of Karthause, and underlies the Pittsburg seam in the same manner as it exists above the Mammoth and below the Primrose in the anthracite measures.

In the Broad Top region the great Pittsburg seam is found on the higher elevations, but too near the tops of the mountains, and covered by too small an amount of the overlying measures to be generally workable. We have not been able to get its exact position and dimensions, but understand its place to be about 400 feet above E, which is its proper position.

The following brief and concise account of this coal-field is from the pen of John Fulton, Esq., the able engineer of the Huntingdon & Broad Top Railroad Company.

VERTICAL SECTION, BROAD TOP COAL-FIELD.

Note.—On comparing figure 113 with 118, the identity of the Broad Top measures with the Alleghany coal measures will be evident and unmistakable. The iron ore under the Mammoth and the Freeport seams is identical, and the position of the Freeport limestone is indicated. The bed of iron ore near B, or between B and C, is not located in this section, but in other sections it will be found. It exists

generally throughout the anthracite coal-fields, and is always found in the same position as the feriferous limestone in the West. The two seams of iron ore indicated—one under the Mammoth and the other over the Buck Mountain bed—are as extensive as the coal-fields or seams they accompany.

BROAD TOP COAL-REGION.

"The Broad Top coal-region, situate in Huntingdon, Bedford, and Fulton counties, occupies a peculiar geological position amongst the coal-fields of Pennsylvania. Standing between the anthracite coal-fields of the north-east and the great bituminous coal-region of the southwest, its coal possesses to a considerable degree the qualities of both, and is therefore classified as a semi-bituminous coal. The region is detached and independent in itself, occupying the southern end of the great synclinal, in the northern end of which the Wyoming coal-field is situated.

"The area of this coal-field has been variously estimated, ranging from 40 to 80 square miles; recent developments, however, seem to indicate the correctness of the latter estimate.

"The region is bounded on the west by Terrace Mountain, and on the east by Sidelong Hill, forming at the northern end a slender synclinal prong, resting its terminal point on the Juniata River below the town of Huntingdon. The coal-field widens towards its southern boundary in Bedford and Fulton counties, ending in a number of terminal fingers. The general topographical features of the region are similar to those of the anthracite coal-fields,—greatly modified, however, in the case of Broad Top.

"The great coal-plateau (from which the name Broad Top is derived) is situated between Trough Creek on the north and Ground Hog Valley on the south.

"The coal measures are regular in structure, with gentle wave undulations, dividing the field into several synclinals or basins.

"The Raystown branch of Juniata River flows along the western flank of the coal-field, winding circuitously through the Umbral red shales, Vespertine and Ponent sandstones, and Vergent slates, which form the western escarpment of the region.

"The construction of the Huntingdon & Broad Top Mountain Railroad was mainly intended to develop the coal-field. The line of the railroad begins at Huntingdon (where it connects with the Pennsylvania Railroad and Canal), and follows up the valley west of the Raystown Juniata until it reaches Stonerstown and Saxton, where it crosses this river and continues along its eastern side to its terminus at Hopewell, where it connects with the Bedford Railroad, extending the rail line to Bloody Run, 43 miles from Huntingdon.

"The Juniata River and Broad Top Railroads form a base-line to the

region. The coal-field is trenched transversely to this base by three streams (tributaries to the Juniata), exposing along their slopes the outcrops of the coal-seams, along which the collieries are located. The three branches of the railroad (Shoup's Run, Six Mile Run, and Sandy Run) have been constructed in the valleys of these streams, connecting with the main road at Saxton, Riddlesburg, and Hopewell, over which the coal is carried to Huntingdon, where it is delivered on the Pennsylvania Railroad track or dumped over schutes into canal-boats.

"The aggregate thickness of the workable coal-seams of the region is 26 feet. A reference to the columnar section will show their order and arrangement. The Broad Top coal has long been known as the best fuel for blacksmithing purposes, and, since the completion of the railroad, has taken an enviable position in market as *the fuel* for generating steam in locomotive, marine, and stationary engines. Its use in rolling-mills, puddling-furnaces, forge-fires, &c. has been eminently successful. It is a white-ash,* free-burning coal, easily ignited, and makes a cheerful fire in grates or stoves, leaving little residuum.

ANALYSIS OF BROAD TOP COAL, BY W. H. ROEPPER, MAY, 1864.

	From Six Mile Run.			From Shoup's Run.			Coke.
	Barnet Seam, Bedford Mine.	Cook Seam, Cunard Mine.	Fulton Seam, Edge Hill Mine.	Barnet Seam, Dudley Slope.	Cook Seam, Broad Top Mine.	Fulton Seam, Prospect Mine.	Barnet Seam, Dudley Slope.
Specific gravity at 4°	1.3110	1.3181	1.3511	1.3087	1.3182	1.3277	....
Weight of cubic yard in pounds	2212	2224	2280	2208	2216	2240	....
Moisture expelled at 120°	.920	.791	.343	.774	.783	.903	....
Bitumen and other volatile matter at red heat.	15.500	13.840	14.075	18.175	17.881	17.807	....
Sulphur	.771	.905	1.036	1.020	.384	1.003	1.260
Ashes	7.337	6.001	11.631	6.694	4.812	9.952	10.800
Fixed carbon	75.472	78.463	72.915	73.337	76.140	70.335	87.940
	100.	100.	100.	100.	100.	100.	100.

"The railroad was completed in 1856, and during the latter portion of that year 42,000 tons of coal were sent to market.

STATEMENT SHOWING ANNUAL SHIPMENTS FROM THE BROAD TOP REGION, FROM ITS OPENING IN 1856 TO 1864 INCLUSIVE.

1856	42,000 tons.	1859	130,595 tons.	1862	334,185 tons.
1857	78,812 "	1860	187,853 "	1863	305,687 "
1858	105,478 "	1861	272,625 "	1864	336,645 "

* The fact of the Broad Top coal being white-ash is an evidence of its identity with the white-ash coals of the anthracite regions. The ash produced by B has not been particularly noted. This seam almost invariably produces red-ash from its lower benches.

STATEMENT SHOWING THE NUMBER, LOCATION, AND NAMES OF COLLIERIES OF THE REGION, WITH NAMES OF OWNERS AND OPERATORS.

Name of Colliery.	Name of Owners.	Name of Operators.	Tons, net, sent to market in 1864.	Estimated value of colliery improvements and fixtures.
Shoup's Run District.				
Prospect	H. & B. T. R. R. Co	H. & B. T. R. R. Co	4,054	$8,000
Crawford	" " "	Miller & Carmon	9,840¼	15,000
Powelton	Powelton Coal & Iron Co	Powelton Coal & Iron Co	67,509	100,000
Barnet	Orbison, Dorris & Co	" " "	35,390	25,000
Burroughs	" " "	Orbison & McGrath	....	3,000
Dudley (slope)	Wood & Bacon	R. B. Wigton	32,482	40,000
Blair's	David Blair	Blair & Port	6,648¼	20,000
Union	Cummings & Hartman	Reakirt & Bro	6,833¾	16,000
Mooredale No. 2	Semi-Anthracite Coal Co	P. Ammerman	10,484¼	15,000
Mooredale No. 1	" " " "	Dunn & Lawrence	7,222	15,000
Broad Top	Jesse Cook	George Mears	32,460¾	20,000
Carbon	H. & B. T. R. R. Co	" "	....	10,000
Cook	Broad Top Improvement Co	Blair & Port	16,595¼	15,000
Friendship	Cummings & Hartman	Reakirt & Bro	....	5,000
Six Mile Run Dist.				
Mount Equity	Riddlesburg Coal & Iron Co	Riddlesburg Coal & Iron Co	17,286	25,000
Duvall (shaft)	H. & B. T. R. R. Co	H. & B. T. R. R. Co	6,545¼	25,000
Brewster	A. P. Wilson & Co	David Dunn	4,784	10,000
Cunard	R. B. Wigton	R. B. Wigton	17,120	20,000
Bedford	Reed, Wilson & Co	Dunn & Lawrence	18,643	20,000
North Point	Six Mile Run Coal Co	Maguire & Givin	2,535¼	10,000
Scott (shaft)	Scott, King & Co	" "	4,540	40,000
Edge Hill	Rathmell Wilson	Noble, Caldwell & Co	52,028¼	40,000
Delaware	" "	" " "	15,346¼	15,000
Fulton	Six Mile Run Coal Co	J. Rommel, Jr	15,355	20,000
Sandy Run District.				
South Point	Hopewell Coal & Iron Co	R. Langdon	2,834	10,000
			386,645	$544,000

"In addition to the above 25 shipping collieries, several new mines are being opened. The Broad Top Coal & Iron Company are opening a colliery up Coal Creek, two miles south of Coalmont; the Huntingdon & Broad Top Railroad Company are opening a colliery near Crawford; the Riddlesburg Coal & Iron Company are opening a colliery opposite their Mount Equity colliery on Six Mile Run. The three branches of the railroad can be extended and new collieries opened as the increase of business may require. The shipments of the region have thus far been retarded by the inadequate supply of cars furnished operators by connecting roads.

"The workings of all the collieries of the region, excepting Dudley Slope, Scott, and Duvall shafts, are above water-level, worked by adits or gangways driven into the hillsides in the coal-seam. From the gangways headings are driven,—generally up the dip,—from which ranges of rooms are laid off: each room is 27 feet wide, with 10 to 15 feet of coal-pillar between. Two miners work in each room, averaging 3 tons each per day. The mine-cars, carrying 2 tons, follow the miners up the middle of each room.

"All slate, whether free from roof or floor, is separated from coal before

loading into the mine-car, so that nothing is sent out of the mine which cannot be dumped into railroad-cars and sent to market. 15 to 20 per cent. is usually allowed in estimating loss of coal in pillars and waste in mining. This expresses the whole loss, being the distinctive feature between the bituminous and anthracite coal-working.*

"As no gases are liberated in working the coal, the means of ventilation are simple. The main object kept in view is to conduct a sufficient supply of pure air through the mine in order to displace the vitiated air where the miners are at work. This is accomplished by natural means, the currents of air being produced by the difference of density between the air of the mine and that of the atmosphere, motion being communicated by the difference in altitude between the mine-shaft and the mouth of the adit or gangway.

"The valley west of the Broad Top coal-field and railroad, stretching along the eastern base of Tussey Mountain, abounds in rich deposits of superior hematite and fossiliferous iron ores, producing, when smelted, the celebrated 'Juniata iron.' The outcrops of these deposits have been traced from McConnellstown, in Huntingdon county, to beyond Bloody Run, in Bedford county, a distance of over 40 miles.

"A furnace was put in blast at Hopewell in September, 1863, receiving its ore from an open quarry of hematite, 15 feet thick, near Bloody Run, and carried over Bedford Railroad. The fossiliferous seams are 3 and 5 feet thick: the latter is the soft quality, and similar to the Montour ore.

"Considerable and deserved attention is now being paid to the iron ores of the region, and explorations in progress are developing new deposits. Large quantities of the fossiliferous ore are being shipped from Pleasant Grove station to Danville for the Montour Iron Works, and from Marklesby station for Conemaugh Furnace. When it is considered, that the Broad Top coke has been found on trial to be a superior *fuel* for smelting these ores, it is singular that this extensive source of mineral wealth should have so long escaped the eagle eye of capital in a region possessing railroad facilities and abounding with all the elements required for its successful manufacture.

"JOHN FULTON,

"*Resident Civil & Mining Engineer H. & B. T. R. R. & C. Co.*

"January 1, 1865."

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* If the common mode of "pillar and breast" is made use of, as we suppose, there is some error in this estimate. The loss must be greater.

CHAPTER XVI.

THE GREAT ALLEGHANY COAL-FIELD.

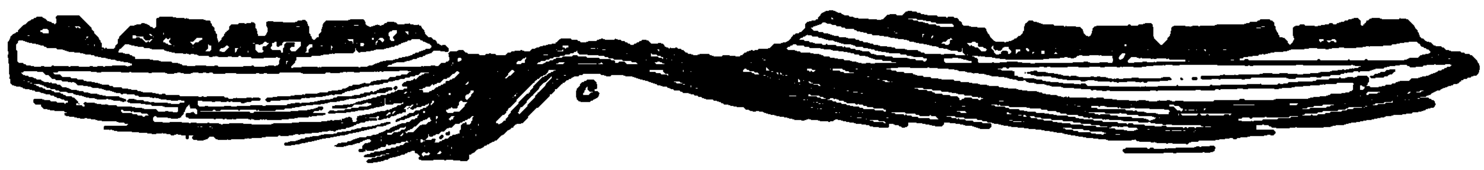
Anthracite and Bituminous—Connecting Coal Formations—Detached Coal Deposits—Ralston, Blossburg, and Barclay Basins—North Mountain Coal-Field—Forests—Oil Territory—Vertical Section through the North Mountain Coal Measures—Identity of Coal-Beds—Barclay, or Towanda Coal-Field—Division of the Coal-Beds—Vertical Section through the Barclay Coal Measures—Character of Coal—The Ralston Coal-Basins—Vertical Section—The Blossburg Coal-Basins—Vertical Section—Identity—Morris Bed—Visit to the Blossburg Mine—"Long Wall" Advancing—Modes of Mining—Relative Cost—Production of the Blossburg Mines—Philadelphia & Erie Railroad—Coal, Lumber, Oil, and Salt—Grades, &c.

In order to trace a connection between the anthracite and bituminous fields, we propose to devote a few pages to the connecting or intermediate basins or bodies of coal which exist as outlying patches along the northeastern margin of the Great Alleghany field. Those deposits are numerous and frequently small, and are scattered through a great extent of country, along the head-waters of the Susquehanna, Juniata, and the Alleghany Rivers. We do not propose to notice them all. It would require more time and space than can be spared; and, under present circumstances, such a description would be neither profitable nor interesting. We shall, therefore, confine ourselves to the northeastern basins, or those lying between the bituminous and anthracite fields.

Those small and detached bodies of coal all belong to the Great Alleghany formations proper, and exist on the high western-dipping plateau peculiar to that great basin. They were originally part of one great and unbroken coal-field. Their present isolated condition is due to denudation; and the deep valleys which separate them are invariably the beds of the present water-courses, cut into the soft red shale, but seldom below it.

Figure 114, from Taylor's Statistics of Coal, is so nearly correct that we

FIG. 114.



SECTION OF THE FORM AND RELATIVE POSITION OF THE RALSTON, BARCLAY, AND BLOSSBURG BASINS.

introduce the original figure here, having purchased the right from Mrs. Taylor, not only to this engraving, but to all others which may be made use of from that work.

The relative distance between those basins is perhaps contracted. The intention is to convey an impression of the general character of those outlying patches, rather than their relative or exact positions. The left-hand basin is that of Ralston, and the right the Blossburg basin. They are separated by the valley of Lycoming and Towanda Creeks, which is over 1000 feet below the level of the coal. The basins of the "North Mountain" and the Barclay coal-field occupy much the same position in regard to each other, and may be represented by the same illustration; though these latter formations are east of the former, and separated by a greater denuded space.

The detached coal-basins along the line of the Philadelphia & Erie Railroad, and the Lock Haven & Tyrone, are similar in character and general formation,—always existing on the tops of the mountains, and always separated by deep valleys cut in the red shale or the soft rocks which are subordinate to the conglomerate, while the conglomerate itself, which caps the mountains and holds the coal as it were in its hollows,—always in basin-shape,—is cut again into numerous smaller patches, as represented in figure 114, by the smaller water-courses.

All this north and northeastern portion of the Great Alleghany formation was originally a vast level or slightly undulating plain, dipping gently to the west and southwest, and covered with an unbroken coal-field, which contained all the seams peculiar to our white-ash series, or below the "barren measures." In fact, it was part and parcel of the Great Alleghany coal-field, as originally formed, and has only been separated from this great body by the forces of the rushing waters which have so materially changed the topographical features of Northeastern Pennsylvania.

THE NORTH MOUNTAIN COAL-FIELD.

This coal deposit lies in portions of Sullivan, Wyoming, and Luzerne counties. The formation is comparatively extensive, though the amount of available coal is limited. It consists of a wide area or plateau of conglomerate, with small bodies or patches of coal scattered over it, occasionally presenting available basins of excellent coal, but more generally containing only the lower bed A, which has been preserved on account of its position in the conglomerate, while the overlying seams have been washed away by the denuding waters.

The entire area of this elevated region, lying between the waters of the north and west branches of the Susquehanna, and drained by the waters of Bowman's Creek, Mahoopany, Loyal Lock, and Pine Creeks, is not less than 500 square miles in extent. Though lying in the midst of a populous region, surrounded by fast-growing cities and towns and encircled by railroads and canals, it is still a *terra incognita*, generally speaking, and

known to but few, and to those few unfavorably. Perhaps the only parties to speak in its favor are the hunters and anglers who still find sport in its deep forests and pure mountain-streams. The hardy pioneers who have repeatedly tried to win a home from the cold and frosty soil have found their labor, patience, and perseverance only rewarded by poverty, privation, and loss. Many have been disappointed in their hopes and expectations based on the level beach ridges and the wide marshes of this upland region. The soils appear deep and rich; but they are cold and clayish, and will not produce grain without an abundance of lime; though the grasses flourish luxuriantly. But, like the poor settlers of Venango, the pioneers of the North Mountain have been rolling among the unlimited wealth of the mineral kingdom without knowing it, or without the ability to profit by it.

The magnificent forests which are or will be worth ten times the mere value of the soil for agricultural purposes, they cut down and burned, with immense labor, and depreciated the value of the land as the reward of their toil. Situated, as this region is, in the midst of or in close vicinity to the great mining districts, where such vast quantities of lumber are used, it cannot fail to become of great value for its timber alone, as most of the available timber in the surrounding country is gone, or fast disappearing. Those deep and magnificent forests must, therefore, soon realize their proper value, and, instead of being burned with incredible labor by the pioneers, they will yield their wealth to the lumberman and the tanner.

This is perhaps the largest and least broken of the outlying patches of the Alleghany formation, and in its geology and topography reminds one forcibly of the great oil-regions of Northwestern Pennsylvania. Though no efforts have been made to develop it, and, we believe, but little attention paid to the subject, we think we hazard nothing in claiming for this region an oil-producing territory at the head of its streams and within the central basins. The position of the upper or "heavy oils" ought to be reached at moderate depth, because its place is immediately below the great conglomerate; but the reservoirs of light oils must lie very deep, because they are below the red shales, yet may be reached in the valleys. The thickness of the strata, however, must be great between the heavy and light oils in this region, since the red shale and the rocks immediately below it are much thicker here than in Western Pennsylvania: there their existence is doubtful, except to a limited extent; while here they are several thousand feet in thickness, according to the general order in the thinning or depreciation of the strata from east to west.

VERTICAL SECTION, NORTH MOUNTAIN COAL MEASURES.

Figure 115 is a vertical section of the measures in the principal body of coal lying within the area described, and near where the Berwick turnpike

crosses the Loyal Lock, east of Old Shinarsville. The lower bed, A, in this basin may extend over an area of 3000 acres, but the upper bed, E, does not occupy one-third of that area. The basin is limited, but the coal is good, and closer to the anthracite in character than any other deposit of the Alleghany formations. It is bituminous in fracture and appearance, but nearly anthracite in character and constituency, and contains nearly 90 per cent. of carbon.

Fig. 115.

VERTICAL SECTION, NORTH MOUNTAIN COAL-FIELD.

In figure 115 we find a close resemblance to the anthracite measures, and a perfect identity of the seams, as a connecting link between the two formations. This is the most eastern of the Alleghany basins, and the nearest to the anthracite fields. It is, beyond doubt or question, part of, and was once connected with, the great Alleghany field; consequently, we need not seek for proof to identify the seams, because, if the measures belong to that great field, the seams must also belong to it, and though they may change in size and relative distances, they will always occupy their proper place in relation to each other.

Our object now is to identify this formation with the anthracite formations, and prove the identity of the respective seams; and, having done this, we submit that the question of identity may be settled as a general application, though we may find difficulty in tracing the seams through all their changes throughout the Western coal-fields. This, however, we believe can be done, and we expect to do it satisfactorily.

Those who have followed us in our descriptions of the anthracite fields, and observed our vertical sections of the respective regions, will at once recognize A, in figure 115, as synonymous with A, or Alpha, in those regions. Here it exists in the conglomerate, and ranges from 18 inches to four feet in thickness, and is found over a large portion of this field in detached deposits, but only occasionally overlayed with the upper seams. We think this seam occupies at least ten times the area of the next overlying seam, and perhaps a hundred times the extent of the upper seam, E. The coal of A is generally bright, pure, and excellent for smiths' purposes towards the centre of the field, but is dull and impure towards its margin to the east.

Immediately above A, and only separated by 20 or 30 feet of coarse sandstones and slates, is B, or the Buck Mountain bed, which is a persistent

seam, and is as extensive as the coal measures. It is the Blossburg and Ralston working bed, and is generally good and productive, though liable to frequent changes. C, or "Gamma," occupies its proper place, and exists in its usual size and character. It is thin here as in the Broad Top coal-field and elsewhere.

D, or the Skidmore, holds its proportion in comparison with the accompanying seams, and occupies its proper place in the measures; though the whole distance from A to E is not greater here than the distance in some of the anthracite basins from D to E,—yet the depreciation of the intervening strata is general and uniform.

E is the Mammoth beyond doubt, and presents its character both in structure and character, as well as its position in the measures. It is a large bed, resembling closely the "Big vein" of the Cumberland region, and is rarely met with in the outlying patches of the Alleghanies. We have been at some trouble and expense in personally investigating this intermediate coal deposit, for the purpose of following closely the change from anthracite to bituminous, and obtaining a connecting link to identify the seams. We submit the result confidently, as the best evidence of the correctness of our propositions.

BARCLAY, OR TOWANDA COAL-FIELD.

The Barclay coal-field lies about 20 miles in a direct line northwest of the North Mountain coal-field, and in the second basin northwest of the Allegheny escarpment,—as the North Mountain is the first, and lying immediately along its first plateau.

The Barclay consists of numerous small patches of coal, lying on the eastern branches of Towanda Creek, and covering an area of about 100 square miles; but of this area not over 10 square miles is productive of workable coal. Most of the productive formation has been denuded,—the streams having cut even through the red shale in many places; but throughout the area of 100 square miles the upper and lower conglomerate forms, perhaps, the largest portion. In the hollows of the conglomerate the coal deposits have been preserved, as before stated, in patches, and as represented in figure 114.

This is the extreme northeastern portion of the second Alleghany basin, and a continuation of the Ralston basin, which, to the southwest, forms the Farrandsville and Snow-Shoe basins, and continues by Ebensburg, Johnstown, &c., as the first basin west of the Alleghanies; that is, the first or North Mountain formation ceases opposite Williamsport, and does not cross the west branch of the Susquehanna River. A deflection of the North or Alleghany Mountains to the west, as far as Lock Haven, removes the Alleghany escarpment between 20 and 30 miles west of the

line of the North Mountain, which forms its escarpment north of the west branch, and between the west and north branches of the Susquehanna. The consequent result is that the first Alleghany coal-basin ceases before reaching the west branch, and the second, or Barclay basin, becomes the first basin south of the west branch, and continues as such into Maryland, where the Cumberland basins arise to the east and become the first Alleghany formation. And here we may call attention to the fact that the Cumberland basins represent the same position in relation to the anthracite formations that the first or North Mountain basin holds. It may be noticed further on that the Cumberland coal measures are closely identified with the anthracite.

In the second basin, or the basins west of the North Mountain and Cumberland basins, the main seams are divided, and form numerous small seams, but holding a close resemblance, nevertheless, and presenting unmistakable evidences of identity. When the beds are divided into numerous thin strata, the intervening space is generally partially filled with fireclay and thin slates, denoting the general quiet which prevailed while the coal formation continued uninterrupted in other quarters. The causes to be assigned for the interruption, in such cases, undoubtedly resulted from an insufficient depth of water, or, in other cases, an excessive depth: either cause is sufficient to account for deficient beds, as is demonstrated in the numerous coal-basins which we have explored. For instance, the deep basins of Pottsville present the lower beds in thin, divided seams, while at the extremities of the same field, where the basins must have been of moderate depth, the seams are largely increased; but invariably, where there exists evidence of a very shallow basin and the absence of the upper seams, the beds are thin and divided by numerous strata of slates and shales.

A section of the Barclay basin presents a general resemblance to that represented in figure 115, with the difference only of a division of the principal seams; and yet they are less "split up" than farther west. We invite attention to this subject, since it leads directly to the conclusion formerly advanced of a division of the principal white-ash beds in a western direction,—a fact which the evidence demonstrates.

NOTE.—Our readers have noticed that we used the word "vein" instead of "seam" or "bed" in the anthracite regions as the local name of the coal-strata. We admit this to be a misnomer; but the habits or customs of a trade or profession warrant the use of such technical phrases as have been adopted by them. The anthracite miners invariably call the coal-beds "veins," though, strictly speaking, veins are never stratified, but refer to mineral veins or lodes which traverse the gneiss or granite rocks without regard to stratification or cleavage.

In future we shall use the proper names to distinguish the coal-strata, either as beds or seams, since the term vein is not used outside of the anthracite regions in reference to the coal-strata.

Vertical Section at the Barclay Mines.

	Feet.	Inches.			Feet.	Inches.
Surface soil	3	0				
Sandstone	5	0				
Iron ore	2	0				
Coal	7	0	E	Coal	3	0
				Slate	0	4
				Coal	1	6
				Slate	0	7
				Coal	2	0
Sandstones, shale, and ore	50	0				
Coal	3	6	D		3	6
Sandstone	31	0				
Coal	3	0	C		3	0
Sandstones, shales, fire-clay, iron, &c.	100	0				
Coal	5	0	B		5	9
Conglomerate and sandstone	20	0				
Coal	2	0	A		2	0

The Barclay coal makes an excellent steam-fuel. It is a dry bituminous, cokes with difficulty or not at all, and contains but a small amount of bitumen and but little impurity. We should judge it to be a good furnace-coal, particularly that of bed B, or the lower large workable seam, and that it might be used raw in the blast furnace.

The coal is mined with much ease, though not on the most economical plan. The size of the seams, the character of the top rock, and the abundance of timber, all point out the "long wall" *advancing* as the true and most economical method in all such localities above water-level.

The Barclay mines are located about 16 miles southeast of Towanda; and a railroad of that length connects the mines with the North Branch Canal at Towanda. The market for the Barclay coal is extensive, and rapidly increasing in the Northwestern cities and manufactories. It is available for most purposes for which anthracite is used, and is also applicable in place of the richer bituminous in many cases. By good management the Barclay mines ought to be very remunerative to the operators. There is a drawback, however, in the uncertainty of canal navigation, and the interruption in winter. A railroad is much needed up the north branch of the Susquehanna, for the development of the resources of this peculiar region, and the transportation of its coal, timber, &c. Yet the energy and enterprise which made the Delaware & Hudson Canal Company—one of the most successful of our coal companies—would effect the same thing for the Barclay Coal Company. Coal enough might be transported during the summer to supply the consumers of the Barclay coal during the winter.

THE RALSTON BASINS.

This is a continuation of the Barclay basin, and consists of a few small patches of the coal measures, containing only the lower beds, which are much divided or "split up" by intervening slates and fire-clays. We give a section, to show the change of the measures in the second basin.

Section at the Ralston Mines.

		Feet.	Inches.	Feet.
Slates and sandstones				20
Coal, C				1
Slates and sandstones				30
Coal, B	Coal	2	0	23½
	Fire-clay	3	0	
	Slate	4	0	
	Coal	8	0	
	Fire-clay	10	0	
	Coal	1	6	
Slates and sandstones				30
Coal, A	Coal	1	0	16½
	Slates, &c	10	0	
	Coal	1	0	
	Shale	4	0	
	Coal	0	6	
Conglomerate				10

The heavy sandstones dividing these seams are consistent with their position in other localities, while the series of thin slates, fire-clays, &c. dividing the seam itself are uniformly consistent with the slaty division occasionally found in the same seams, even when solid to all appearance. The partings are nearly always to be seen, but of smaller dimensions where the seams are compact.

THE BLOSSBURG BASIN.

This, as before observed, is nearly west of the Barclay and Ralston, and is the northwestern extremity of the third Alleghany basin. The coal here contains more bitumen than the Barclay, but still is classed among the dry, free-burning, bituminous, or steam coals.

The Blossburg mines are located in Tioga county, Pennsylvania, and are about 40 miles east of Corning, on the York & Erie Railroad, with which they are connected by rail. The location of this, the third basin, is about ten miles northwest of the second basin at Ralston.

Like all other detached basins of the Alleghany coal-field, this is an assemblage of coal deposits, separated from each other by deep erosions,

but forming part and parcel of the great original coal-field which once existed unbroken throughout this vast region, now broken into detached basins and elevated plateaus by the denuding action of water. The area occupied by this portion of the third basin is probably about 50 square miles, of which one-half may contain the lower seams.

Section at the Blossburg Mines.

	Feet.	Inches.		Feet.	Inches.
Coal	3	0			
Slates, &c.	20	0	E	28	0
Coal	5	0			
Sandstones				40	0
Coal	2	6	D	2	6
Sandstones and slates				30	0
Coal	1	6	C	4	6
Fire-clay	3	0			
Slates				20	0
Coal, Morris bed	3	6			
Fire-clay	5	0			
Coal	2	0			
Slate	5	0			
Coal	1	0	B	30	0
Slate	3	0			
Coal	0	6			
Slates	6	0			
Coal	4	0			
Slates, sandstones, &c.				40	0
Coal			A	1	6
Conglomerate				0	0

During our last visit to the Blossburg mines, by the invitation of Dr. Morris, of the Blossburg Company, we spent a day with much pleasure in going through the mines and examining the works. The Morris bed was the only one worked at that time by the company. It is the upper part of the lower seam B, according to our judgment, and makes a bench of beautiful and pure coal. The location of the mines was a serious error, since the gangways are confined to a limited area, on account of the dip of the seam, which is from the gangways on the lower side. Instead of opening the coal on the west face of the mountain, or the Blossburg side, the opening was made on the southeast side, or, rather, towards the top of the plateau. This error not only led to a great expense in building the railroad up the mountain, a distance of several miles, but also located the mines to the *rise* of the coal, or towards the outcrops; while a location on the front face would have been much more available not only for the drainage of the mine, but much more economical for mining and shipping.

We understand some of these difficulties have since been removed. We merely make these remarks, as we have done on several occasions, to call attention to these often-repeated errors of location which arise from the want of a little geological and mining experience.

The gentlemen in charge of the Blossburg mines at the time of our visit were not, however, responsible for the errors, since they had been committed before their administration. We shall not soon forget our ramble through these mines, or the exertions we made to keep up with Mr. Young during a long walk on "*all-fours*" through the intricate avenues of a three-feet flat seam. But the pleasure derived from seeing for once in this country the "long wall" advancing practically in use, compensated for our labor.

The coal from this small seam was mined about as cheaply as the coal from our 30-feet Mammoth seam in some localities. The miners had always one "loose end," and the breasts, or chambers, were carried wide. The bogies, or small cars, had broad, flat flanges, and would run with as much ease on the hard bottom-rock of the seam as on the rails: therefore these small cars were taken direct to the coal, and a single handling only was required.

There is at least one-half difference in the cost of mining the same coal. That is, the best mode is one-half less expensive than the worst mode: the best is the long wall, or the "board and wall;" and the worst, the narrow chambers and parallel pillars. The most expensive mode is more frequently practised in this country than the most economical.

Below will be found the statistics of coal shipment from the Blossburg mines.*

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* CORNING, N. Y., July 31, 1865.

S HARRIES DADDOW, ESQ.:

DEAR SIR:—Yours of 27th inst., requesting to be furnished with statement of coal-shipments over the Blossburg Railroad, is received. Below I give you account of coal-shipments from Blossburg to Corning for a series of years.

For year ending October 31, 1853	45,507	tons.
" " " " 1854	70,214	"
" " " " 1855	73,204	"
" " " " 1856	70,669	"
" " " " 1857	94,814	"
" 14 months ending Dec. 31, 1858	41,894	"
" year " " 1859	48,592	"
" " " " 1860	96,918	"
" " " " 1861	112,712	"
" " " " 1862	179,334	"
" " " " 1863	235,843	"
" " " " 1864	384,977	"
	1,454,178	" 2000 lbs. each.
For six months ending June 30, 1865	52,857	"

Yours, respectfully,

A. C. STEARNS,

General Agent Tioga Railroad Company.

THE PHILADELPHIA & ERIE RAILROAD.

This railroad runs along the northwestern margin of the main Allegheny coal-field, from Lock Haven to Warren. At several points this line cuts into the main coal-field, which extends unbroken to the south and southwest; but to the northeast the coal exists only in patches, as we have described. At a few points along the line of this road the lower coals, as described in the Barclay and Blossburg coal-fields, exist in considerable bodies; but generally the field is much broken, and only the bed B exists in workable quantities. Coal is mined at the Eagleston and Tangascoolock mines, a short distance above Lock Haven; at or near Cameron Station, Renova, Ridgeway, Johnsonburg, and at other points along the line. A New York company are operating near Cameron, and a Boston company are building a road 11 miles long to connect their mines with the Philadelphia & Erie. Besides these, many small operations are under way, and considerable coal has been mined and shipped along the road westward to the oil regions, where large quantities of coal are required to supply the engines employed in boring and pumping. Coal has been sold during 1864 in the oil regions at one dollar per bushel, or $30 per ton; but we believe the average price of coal by the car has been about $10 per ton.

A few years ago, a great portion of the region through which this road passes was simply a wilderness. But now, from Lock Haven to Correy, towns and cities are growing up as if by magic. Lumbering establishments dot the road through all this wild region, and immense piles of sawed lumber crowd the trains or are stacked along the line. The quantity of timber seems immense; but, at the rate at which it is disappearing, those immense forests will not darken the soil or harbor the game much longer. Coal-mines are opened and the minerals developed rapidly, while salt-wells and oil-wells not only exist in Venango, but from Lake Erie to Warren, and even farther east.

The grades and distances of this line from east to west are more favorable than those of any other line connecting the Eastern and Western waters.

The distance from Philadelphia to Lake Erie, *via* Lancaster, Harrisburg, and Sunbury, is 447 miles; while the distance from New York to the Lakes is 508 miles by the Erie and 535 by the Central road. The distance, however, from New York to Buffalo or Dunkirk is considerably less. The elevation overcome by the Philadelphia & Erie is 2006 feet, and the ascent is gradual. The elevation overcome by the Pennsylvania Central in crossing the Alleghanies is 2161 feet, and the ascent is more irregular. The Baltimore & Ohio overcomes an elevation of 2620 feet, and contends with sharp curves and successive descending and ascending grades.

The item of elevation, and consequent heavy grades, in crossing the Alleghanies, or connecting the Eastern and Western waters, is an important one. Grades of 100 feet to the mile are difficult to overcome, and the expenses of transportation are increased in proportion to the increase of the grades. For a heavy traffic, the Philadelphia & Erie is the most favorable line yet built. But it simply taps the Lakes. True, they supply a vast trade, which is constantly on the increase, and will eventually tax to the utmost all the roads leading from them to the East. Yet, when we consider the productive area of the Mississippi Valley, the region from which and to which the greatest streams of trade must eventually flow, and where men and cities will be thickest, we cannot shut our eyes to the natural advantages possessed by Virginia, or conceal the fact that a little enterprise and capital might give to that State the chief trade of the West. Had the Virginians a tithe of the energy and vigor manifested by the people of Pennsylvania and New York, the magnificent roads at Hampton would ere this have been crowded with shipping from all parts of the world, engaged in peaceful traffic, their cities and villages would now be flourishing and prosperous, instead of lying in smoking ruins, and the fields and mountains of their State would be productive of wealth, instead of being clothed in weeds and "old field pines" and still almost unknown to the miner and the manufacturer. But we shall refer to this again in a more appropriate place, and will continue our description of the coal-field.

It will be noticed on the accompanying miniature map that we have been skirting the great coal-field, and simply describing the outlying patches which cluster along its northeastern margin. We will now present a concise account of the entire field, having given the foregoing chiefly for the purpose of connecting the anthracite with the bituminous coal-fields.

CHAPTER XVII.

THE GREAT ALLEGHANY COAL-FIELD.

Map of the Alleghany Coal-Field—Extent and Boundaries—Area in the several States traversed—Basins—Anticlinals—Coal Measures—Thickness—The Great Basin—Transverse Section—Description—Coal Measures, Character, and Variation—Cannel-Coal Beds—Vertical Sections—Identity of the Coal-Beds—Mammoth and Karthause—Primrose and Pittsburg Beds—Professor Lesquereux—Palæontological Evidence—Anvil Rock—J. P. Lesley—Identification of the Lower Beds—The Great Kanawha Region—Alleghany Coal-Field in Pennsylvania—Production of Bituminous Coal in Pennsylvania—The Cumberland Coal Region—Erosion—Sections.

DESCRIPTION OF THE MAP.

The accompanying miniature map represents the general extent and form of this great coal-field, with the prominent places and points. It extends through portions of nine States, viz.:—Pennsylvania, Ohio, Maryland, Virginia, West Virginia, Kentucky, Tennessee, Georgia, and Alabama. Its immediate boundary in Pennsylvania, not including the outlying patches, extends from Lock Haven, on the west branch of the Susquehanna, along the Alleghany range, southwest, through the counties of Clearfield and Cambria, to the Maryland line, and northwest, through the counties of Clinton, Elk, McKean, Warren, Crawford, and Mercer, to the Ohio State line at Greenville,—embracing a productive area in Pennsylvania of about 12,000 square miles, independent of the smaller outlying deposits before noticed. The prominent places near which the coal-margin passes in its northwestern border are Lock Haven, Farrandsville, Defiance, Emporium, Smethport, Ridgeway, Johnsonsburg, Warren, Tideoute, Franklin, and Greenville. The boundaries of this great coal-field continue from Greenville, in Mercer county, Pennsylvania, west through Trumbull, Portage, and Summit counties, Ohio, to Akron. The boundary-line thence runs nearly south through Ohio to the Ohio River, near Portsmouth; crossing the Ohio into Kentucky, it changes its course rather more to the west, but continues in an irregular line through that State into Tennessee; pursuing the same southwest course, it crosses the State of Tennessee half-way into Alabama. In that State, near the Mississippi line, it forms the southern boundary, and returns by the eastern margin, in a general northeast course, through Alabama, North Georgia, Tennessee, and Virginia, to the Great Kanawha, near the mouth of the Greenbrier. Soon after crossing at this point it attains

its maximum breadth, and changes its course nearly north to the Maryland line.

The length of this coal-field within its productive area is 800 miles, or to its extremity at Blossburg 875 miles. Its maximum breadth from Cumberland, Maryland, to Newark, Ohio, is 180 miles. Its minimum breadth is on a line with Chattanooga across the field, where it is not, perhaps, more than 30 miles wide. The entire area is about 55,000 square miles, which is divided among the States in which it lies in about the following ratio:—

	Square Miles.
Pennsylvania	12,656
Ohio	7,100
Maryland	550
West Virginia	15,900
Kentucky	10,700
Tennessee	3,700
Alabama	4,300
Georgia	170
Total	55,076

The general form of this great coal-field is that of a rude club, the handle ranging through Kentucky, Tennessee, and Alabama, and the head resting on Virginia, Ohio, and Pennsylvania.

The northern extremity terminates in five prongs, or Titanic fingers: this we have not represented on the map, since the scale is too limited to admit of this feature being portrayed; nor have we marked the prominent anticlinals of Negro Mountain, Laurel Hill, or Chestnut Ridge, which range longitudinally along its eastern margin through the southern portion of Pennsylvania, Maryland, and part of West Virginia.

The field undulates from east to west, forming six principal basins and five prominent anticlinals, independent of the Maryland basin. The eastern axes are more abrupt and narrow than the western, as shown in figure 4, which conveys an approximate idea of the general form of the field. The coal measures are divided by Rogers and other geologists into three or four series or groups. We do not propose to make more than two divisions, into which the coal measures are naturally divided. That is, the lower beds, under the Mahoning sandstone, corresponding with our white-ash coals in the anthracite regions and the upper beds, or those above this sandstone. The lower group naturally occupies much the larger area, on the principle represented in figure 92, where it may be noticed that the lower beds occupy a much larger area than the upper ones, though the strata pitch much more abruptly in the anthracite than the bituminous regions.

In figure 92, A, B, C, D, and E constitute the lower group of white-ash seams, as they constitute the lower group in the bituminous fields. But here they spread out in a nearly horizontal manner, and, of course, cover a correspondingly greater amount of area.

In all probability, the lower beds occupy three-fourths of the entire area of this field, where the upper beds do not exist: that is, the upper beds, or those lying over the Mahoning sandstone, do not occupy more than one-fourth the area of the coal-field. The upper beds, in fact, are confined to a limited area, as the red-ash beds are in the anthracite fields. They occupy a portion of this field in the southern part of Pennsylvania, Maryland, Virginia, and Ohio, and may exist to a limited extent in the deepest portions of the measures in Kentucky. But in the Western coal-fields the upper beds do not exist.

The numerous water-courses that traverse all parts of this great field have cut deep valleys through the coal measures, in many places far below their base; but generally the valleys exist in the coal measures and at the expense of the coal. Not less than one-third the entire amount of coal has been thus denuded by erosion. It will, therefore, appear evident that we can only estimate approximately the total thickness of coal; since none but the lower beds approach the margin of the field, and the upper beds occupy but a small area, while all portions of the field have suffered much from erosion. The total thickness of the seams ranges from 50 to 75 feet: perhaps 50 feet total workable thickness would be an average, where the upper and lower groups exist. But we cannot estimate more than half the aggregate thickness as productive throughout the entire field. We have given 30 feet as the total workable thickness of the coals of Pennsylvania, and 20 feet as the aggregate of the United States; and both are the maximum limits. The amount of available—or what we now call workable—coal is much less; but, under a system of economy that might and should be applied to our coal-beds, perhaps the estimate is reasonable, and it is certainly within the bounds of all such calculations. Under our present wasteful style of mining, however, and our rejection of all seams under three feet as unworkable, the estimate is one-half too much; that is, the productive yield of this great coal-field would be fifteen feet total thickness, instead of 30 feet,—22,500 tons per acre, instead of 45,000 tons. But here, as in the English coal-fields, we have estimated all seams over 12 inches in thickness.

THICKNESS OF THE ALLEGHANY COAL MEASURES.

There are several interesting geological problems connected with the coal measures of this great field, which if satisfactorily settled would go far to determine a scientific question of some importance. As before stated, all coal-fields are basin-shaped, and the interior is always deeper than the

exterior portions,—in other words, the centre of the basin is always deeper than its outcrops; and this fact holds good in the Alleghany field as elsewhere. But here, as in most other fields, the coal is deposited in numerous basins, lying parallel with each other and conforming to the general geological strike of the strata. That is, all our mountain-ranges have a general southwest and northeast course, and all our great valleys, and consequently basins, have the same general strike of axis, while their transverse is, of course, the contrary. But these basins are successively deeper as they range from the west towards the east, or from the centre of the Great Appalachian (Mississippi) Valley. This depression is not only from the west to the east, but also from the north to the south; and, though there is now no external evidence of a southern margin to the great basin, nothing is more certain than that a southern margin must have existed, as high, perhaps, as the boundaries on the east, north, and west. But these boundaries of the great basin, or the ancient Appalachian sea, as described in Chapter III., are not the boundaries of the Alleghany coal-field; for besides this great field there are two or three others, perhaps not less extensive, and several of smaller dimensions, but all within the great basin. As before noticed, the eastern margin of the Alleghany field is the eastern margin of the great basin as it now exists; that is, this field lies on its eastern side, while the Rocky Mountains and their unexplored coal-fields bound it on the west. But the western margin of the Alleghany field lies towards the deeper portions of the great basin, and, as we have said, in the eastern portion of Ohio. Its extreme southern limit lies far in Alabama, and on the summits of the mountains which tower over the vast plains of the Gulf. The abrupt termination of the field in this direction, and the broken crags which form the terminal points of many of those great mountain-ranges which sweep down from the north along the eastern margin of the great basin, and which form its Atlantic boundary, indicate a violent change in the topography of the South. The continuation of the coal-field was evidently far beyond the "Lookout" ranges, and its present southern area bears no comparison to its ancient extent when first from the hand of Nature.

Yet, while we consider the southern margin of the ancient sea to have been along the shores of Florida and the mountains of Cuba and Yucatan, we have no reason to suppose that the coal formations originally existed universally along their interior slopes. It seems evident that the subsidence of the crust was greatest in this direction, and that the interior basin must have been always too deep to admit of the formation of coal. But around the entire basin we find coal wherever there is evidence of a comparatively shallow sea. The depression of the ancient granitic or igneous crust of the earth, and the elevation of the Palæozoic or sedimentary strata, have been general along the southern and eastern margins of the

ancient sea. The change was natural, and, we think, has been clearly set forth in Chapter III.

It will be necessary here to devote a few words to the form and character of the great basin in which not only the Alleghany coal-field but the other great Appalachian fields, which will follow in this description, exist. The accompanying illustration, figure 117, represents the general form of the great basin from east to west, on a line with the Great Kanawha, Ohio, Missouri, Kansas, and Arkansas Rivers, from the Alleghany to the Rocky Mountains. The section is necessarily approximate, and merely gives the general positions of the great coal-fields, and the order of the geological formations and their peculiarities.

The outside granite edge of the great basin is 6000 feet above the sea in Southwestern Virginia, at the head of the New River,—a continuation of the Great Kanawha,—and from 10,000 to 15,000 feet high in the Rocky Mountains. The succeeding gneissic belt has less elevation, and succeeds the granite not only on its western but on its eastern side, and laps over the granite on the margin of the great basin almost vertically, and in the interior horizontally. Derived from volcanic eruptions or the line of volcanic vents existing in the granite belt of the east, it naturally overspread the granite on both sides of this elevated belt, and covered it in all the deep valleys or lower basins. This belt of gneissic or azoic rocks is succeeded by the Palæozoic or sedimentary strata *d*, represented in the Alleghanies on the east and the Black Hills on the west; and on or in this exists the coal.

We must here state that our section is conjectural in its western margin so far as the coal is concerned, and also, to some extent, the form of the Palæozoic strata. The general form and character of the western margin of the great basin must partake to a great extent of its eastern features; but we cannot state from personal observation that the effects of volcanic action were the same, or that basins for the formation of coal were created in the same manner as they were to the east. It is possible that the greater elevation of the western margin left the larger portion high and comparatively dry before the advent of the coal era, or the period of time when the heat was tempered to the proper degree to permit the growth of vegetation.

The section we give is miniature in scale, since we have to comprise 1500 miles in seven inches: we can, therefore, only portray the chief points within the great basin.

The Alleghany coal-field, which is 180 miles wide, is the first, and lies along the eastern side. It is separated from the Central coal-field by the Devonian and Silurian formations of Ohio and Indiana, which are over 100 miles wide. The Central coal-field is as wide as the Alleghany. It will be noticed, in the small maps which we give of these fields, that

Fig. 117.

a *a*

THE GREAT APPALACHIAN OR MISSISSIPPI BASIN.

In order to present a clear comprehension of the great basin, we will describe the illustration separately from the text. *a* is the sea-level; *b* is the granitic peaks of the mountains between North Carolina and Virginia, 6000 feet above the sea; *c* is the gneissic or azoic formation; *d*, the Palæozoic (including *e*, *f*, &c.), which is 20,000 feet thick at *d*, and only 3500 at *i*, in the Central or Illinois coal-field; *e* is the oil strata of Pennsylvania and Virginia, and the Carboniferous limestones of the West; *f* is the Great Alleghany coal-field; *g* is the Ohio River, at the mouth of the Great Kanawha; *h* is the recurrence of the Devonian and Silurian strata of *d*; *i* is the Great Central coal-field of Indiana and Illinois; *j* is the Mississippi River, near the mouth of the Missouri; *k* is the Great Western coal-field; *l*, the Missouri River, where it bounds the Western coal-field and turns north; *m* is the Kansas and Arkansas coal-field; *n*, the upper or tertiary coals of the West; *o*, the Black Hills and their accompanying coal; *d* is a conjectural repetition of the formations of the East; *c* is the presumed form of the gneissic formations in the western boundary of the great basin, and *b* is the granitic peaks of the Rocky Mountains; *a*, the sea-level, 10,000 feet below the peaks. The perpendicular double lines at *e*, *c*, represent the Eastern Palæozoic column, and the double lines at *i*, *b*, the Western Palæozoic column in Illinois. The accompanying figures represent the thicknesses respectively. The figures above the sea-level represent the elevation of the respective points above tide.

the scale in the Alleghany map is 100 miles to an inch; while it is only 50 miles to an inch in the Central, and ⅞ of an inch to 50 miles in the Western field. The *Western* field in Iowa and Missouri is also from 150 to 200 miles wide. The extent of the coal in Kansas is conjectural; and the same may be said of all to the west of the Missouri River where it leaves or bounds the Great Western coal-field in Missouri. It is, perhaps, scarcely to be doubted that the Central, Western, and Arkansas coal-fields were once united and formed one immense area of coal nearly, if not fully, 500 miles square, or embracing an area of 250,000 square miles.

The coal depreciates rapidly westward, and only two or three small seams exist in Western Missouri. Westward still, however, we find coal and coal formations; but most of the coal west of Missouri and east of the Black Hills is tertiary coals or lignites, formed, in all probability, in the marshes and bogs of that higher region; while the coal formed in the deeper basins to the east.

The Eastern coal-basins dip below the sea-level; while the Western basins, even in Missouri, lie from 400 to 800 feet above it; and while the Silurian rocks descend from 20,000 to 30,000 feet below the coal in the East, they do not, perhaps, reach the sea-level in the West. It will be noticed that the ascent is gradual towards the West, and that the Western coal-fields are more uniformly level or partake less of the basin-shape than the Eastern fields. While the Alleghany field presents the basin-formation prominently, the Central coal-field is only moderately basined, and the Western coal-field is nearly horizontal. The evidence presented here is conclusive as to the formation of coal in water; and the deeper the basins the more extensive are the measures and the more numerous the coal-seams. The sections presented farther on demonstrate this fact conclusively. Vertical section, figure 118, through the Alleghany coal-field, presents 50 feet of workable coal; while that of the Central coal-field, figure 128, shows only 20 feet, and that of Missouri, figure 131, only 10 to 15 feet.

We must conclude, therefore, that a shallow depth of water, forming bogs or swamps, was not a favorable condition for the production of coal; and this fact is strong evidence that true coal is not the production of an arborescent flora. The basin-shape, as presented in irregular formation, also condemns the theory of the *elevation* of the submerged portions or the deep basins above water-level. It is not probable that they would be elevated and depressed in spots: such a phenomenon would be unnatural. The elevation or depression must be gradual and general. But we discard all such unnatural processes in the formation of coal. The general depression of certain portions of the earth's crust we showed to be consistent with the natural processes, and, though not absolutely necessary to the formation of coal, yet not inconsistent with its formation in deep basins; while the facts here presented demonstrate the propositions

formerly set forth,—that coal is formed in comparatively deep basins from the bituminous results of naphtha or carbon oils in connection with an aqueous flora, and perhaps the oils of an arborescent flora, compressed within the coal-strata and rising to the surface of the water, as all oils must do when released from confinement.

THE COAL MEASURES.

That the Palæozoic strata thin or depreciate in a westward direction has been clearly demonstrated; and we may presume that the coal measures are no exception to the general rule.

But the depreciation of the coal measures bears no proportion to the depreciation of certain subordinate rocks. We have seen that the Palæozoic column at Pottsville is from 30,000 to 40,000 feet in height; while in the Central coal-field, in Indiana and Illinois, it is less than 3500 feet. But while the coal measures in the anthracite regions, within the productive strata, are 2500 feet thick, the coal measures of the Great Alleghany coal-field are about 2000 feet thick within the productive measures; and while the coarse sandstones accumulated in the former region, the slates, shales, &c. formed in the latter; while the immense beds of *anthracite coal* were forming in the *East*, *limestones* accumulated in the *West:* both required seasons of rest and quiet. Therefore, less depreciation appears in the coal measures than in the rocks on which these measures rest. In figure 117 the measures or coal-fields appear to depreciate rapidly in a westward direction, and this is really so. But this depreciation is due more to the absence or want of the measures containing the upper coals than to a thinning of the strata.

The Pittsburg coal G does not exist west of the Ohio to any great extent. It may appear on the highest points of the Illinois Central coal-field, but never westward of that locality.

The natural position of the Mammoth, or E, is beneath the Mahoning sandstone, and as the Primrose, or G, is the next seam of importance above this sandstone, we must assume it to be the Pittsburg bed. The evidence of this identification is complete. First, the distance from A, or the conglomerate, in the Pottsville section, or in the anthracite regions generally, to E, or the Mammoth, is about 400 feet, and the distance from A to E in the Alleghany coal-field is generally about 300 feet. Second, the iron ore over the bed B, accompanied by limestone, is identical with the ores found over the Buck Mountain bed in the Lehigh region, at Barclay, in Bedford county, and elsewhere in the East. Third, the iron ore under bed E is almost universal throughout the anthracite regions, and in many places in the East it is accompanied by a coarse, calcareous rock, identical with the "Curlew limestone" of the West. Fourth, we have, in our description of

the principal seams in the anthracite regions, called particular attention to the "splitting" of the beds in a westward direction, and demonstrated that the Buck Mountain B and the Mammoth E each divided into several seams as they ranged westwardly; and, if we notice the sections made in various Western localities, we will find that these great beds have their representatives in their proper places and in uniform order, or are represented by groups occupying their proper geological horizon.

We must here call attention to a singular fact—for such we presume it to be—in regard to the cannel-coal seams. These seams have no fair representatives in the anthracite regions, and are not to be identified generally in the West. They always exist between the great beds, and increase and decrease, and improve and depreciate in quality, according to the uniformity of the measures and the accompanying bituminous beds. Sometimes these cannel seams are represented by a small strata of pure bituminous coal, and at other times by a bed of bituminous shale, which changes from shale to bituminous coal, splint, and cannel, according to circumstances.

The first cannel seam exists over B, and is synonymous with our C, which is always a variable seam, and generally small. The next is a split from E, and is one of its lower benches. This seam is not reliable, and only occasionally cannel; but sometimes it is very good, and 3 feet thick on the Kanawha. The next and last cannel seam exists over the Mammoth, or E, and is sometimes from 5 to 6 feet of splendid cannel coal. It may be the "seven-feet" seam overlying the Mammoth. This is supposed to be the celebrated Peytona* cannel of Coal River, in West Virginia.

The lower cannel, or C, is the most extensive, and the seam generally productive of cannel coal in the West. We have named it "Gamma" in the anthracite regions.

In figures 76 and 118 will be found an identification, nearly, of the anthracite beds with the bituminous seams of the Alleghany coal-field. The size of E, as given in figure 118, is larger than given by Rogers, Lesley, or most of our geologists who have written on the bituminous coal-fields. But it appears evident from the State Survey, and the facts which may be gathered concerning this seam, as the "Elk Lick coal" in Somerset county, Pennsylvania, the great bed at Karthause and Clearfield, Pennsylvania, and the great upper coal-bed on the Kanawha and Coal Rivers in West Virginia, that E is equally as large as G. In fact, this bed is frequently larger than the Pittsburg seam, and as good and pure, but it is not quite so regular. The same may be said of the Mammoth in the anthracite regions; though the Primrose bears no comparison to it there.

* There is some doubt in relation to this seam; we are not certain as to its identity. Late developments seem to place it above E; but Lesley places it above B, and synonymous with C.

Fig. 76.

Fig. 118.

Cannel.

Cannel.

Cannel.

VERTICAL SECTION AT POTTSVILLE, PA.

VERTICAL SECTION, ALLEGHANY COAL-FIELD,—GENERALIZED.

There can be no doubt of the fact that the great Cumberland bed is identical with E, or the Mammoth. It has been mistaken for the Pittsburg bed; but a careful examination of its position, character, and accompanying seams and strata will convince any practical man of this identity. From the efforts to identify this great bed with the Pittsburg bed much confusion has arisen. This has led many to suppose the Mammoth and the Pittsburg bed synonymous; and from this error in the starting-point has arisen all or most of the difficulty in the identification of the seams.

Prof. Rogers has also made errors in his sections at Wilkesbarre and Pittston, which, we observe, has led Prof. Lesquereux, of Columbus, Ohio, into some confusion in his Western sections; and in this respect Prof. Lesley seems also, for once, to have been led into error.

We do not, however, make these remarks with invidious intention, since these distinguished geologists are entitled to our admiration for their eminent services; but we wish to point out the necessity of starting right and the importance of correct data.

We think Prof. Lesquereux has the data for a complete identification of Western coals. We notice the facts which he has established by his palæontological researches, or a comparison of the fossil flora and organic remains accompanying the respective seams; but we notice, also, that he has placed too much reliance on imperfect sections, and, while he accepts imperfect data for fact, it will be impossible to arrive at any general and definite conclusion. We must acknowledge, however, that we owe much to Lesquereux and Lesley for the conclusions we have arrived at; but, in order to make their data available, we have spent much patient labor and made many arduous personal investigations of doubtful points and localities in order to justify and connect the facts they have elucidated with developments set forth in the preceding pages in reference to the identification of the seams.

Lesquereux says, "From all the local sections of the Pennsylvania survey, two ascertained data are especially worth mentioning. 1st. The reliability of our Curlew limestone, which in Pennsylvania is called Freeport limestone, and is generally placed 6 to 15 feet above our No. 3 coal. 2d. The consistency of the *ferriferous* limestone between No. 1, B, and No. 2, in the place occupied by our coal C. It lies, as in Kentucky, 10 to 40 feet above No. 1, B, and is generally accompanied by calcareous ores."

It thus appears that the "Curlew limestone" lies below E and between E and D; and Lesquereux denominates E as No. 4, and he finds by palæontological evidence that No. 4 of Western Kentucky is also in the vicinity of the Baltimore bed at Wilkesbarre, Pennsylvania; and, since we have identified the Baltimore bed beyond a doubt with the Mammoth of Schuylkill county, Pennsylvania, this fact is thoroughly established, and there

can be no room for doubt that the Mammoth is identical with the Freeport beds or the seams of that group.

Lesquereux also identifies B of our nomenclature with B No. 1 in Western Kentucky; but he falls into error by calling B, or the Buck Mountain, "*the Mammoth.*" But this error evidently arises from the confusion of the Wyoming sections made in the State Report; and this simple misnomer cannot invalidate the facts set forth in the foregoing quotation from Lesquereux's palæontological report in the Kentucky survey.

From this and other errors arising from incorrect data, we think this eminent professor of palæontology has fallen into the mistake of placing all the coal-seams of the anthracite regions of Pennsylvania beneath the Pittsburg bed, or even below the Mahoning sandstone; whereas all the evidence goes to prove that the highest coal at Pottsville is at least cotemporaneous with the "Anvil Rock," the counterpart of which may be found over our K, or the Tracys. It is not only the hardest rock in the coal measures, but to all appearance, except in thickness, it is the perfect counterpart of the Anvil Rock of Kentucky.

In treating of the lower coal,—viz.: our white-ash coal of the anthracite regions,—Prof. J. P. Lesley, in his "Manual of Coal," agrees precisely with us in their distribution and character.

"The Lower Coals form in Western Pennsylvania a system by themselves, as has been said already. Clinging as it were to the face of the conglomerate, the lower system fared better than the upper one, and has been left to cover an immense area. In fact, it forms by far the largest part—perhaps four-fifths—of all the coal remaining on the surface. In Ohio—except near Wheeling—and in all the Western States, it is the only coal, and may have been originally the only coal deposited.

". . . . Wherever the dip is gentle, this lower coal system prevails, the upper being swept away; but where the dip is steep and in the middle of the narrow troughs, it receives the upper system on itself. It furnishes the beds of Northern and Western Pennsylvania as far south as the Conemaugh or Kiskiminetas, those of the Alleghany River, and all the country northwestward of the Ohio. It occupies the west and south of Virginia, and provides the coal of Kentucky* and Tennessee. The cannel is, perhaps, exclusive of this system.

". . . . At that time [referring to the early survey of Pennsylvania] a large bed in the upper part of the system was familiarly called the 'Elk Lick coal,' from its locality near the romantic falls of that name in Somerset. This bed, which is the upper Freeport bed of the Kiskiminetas and Alleghany Rivers, seems to be represented by the large upper coal of the

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* This refers to Eastern Kentucky, or the Alleghany coal-field in Kentucky, and not the coals of the Central coal-field in Western Kentucky.

Kanawha and Coal Rivers of Virginia, and by the great bed at Karthause and Clearfield to the north. It marks the upper limit of the lower coal-beds, and is covered at no great distance by the remarkable sandstone strata hereafter to be discussed [the Mahoning sandstone].

"This coal-bed sometimes rivals the Pittsburg bed in size and purity of minerals, but wants its regularity. This is its fault in common with all the beds of the lower system: they cannot hold their own for any great distance in any given direction. This is particularly true of the large bed B [Buck Mountain], which lies nearly upon the conglomerate, and seems coextensive with the coal-field.

"At Towanda, on Broad Top, at Johnstown, on the Tennessee River, even at St. Louis, its sections are scarcely to be told apart. Everywhere it is about 50 feet above the conglomerate; everywhere it has a small satellite some yards below it; everywhere it is itself a variable stratum from five to twenty feet in thickness,—a double bed, with an even roof and an uneven floor, rising and falling stormily on a sea of fire-clay, which sometimes has a depth of thirty feet."

This terse and graphic description of the lower coals demonstrates clearly the identity of the Mammoth with E, or the Freeport beds, and B, or the Buck Mountain, with the last-named. In fact, the identity is minute and unmistakable, as any one who has followed us will determine. It places the Mammoth, E, beyond a doubt immediately under the Mahoning sandstone; and, since the Pittsburg seam is immediately above it,—the small seam F only intervening,—there can be no doubt in relation to its identity with the Primrose, or G.

It may be noticed that all our sections invariably show a small seam, A, under B, and our description of B will be found to agree fully with the foregoing quotation, with which we not only coincide, but offer it in evidence of the correctness of our propositions. We may, therefore, presume the identification to be complete and satisfactory; while the evidence is such that there can be no difficulty in tracing the respective seams through all our American coal-fields, or those of the true Carboniferous era. The bed B, lying about 50 feet over the conglomerate, and over it the fossiliferous limestone and iron ore; the beds E, immediately under the Mahoning sandstone, and in the vicinity of the Curlew, or Freeport, limestone; and the Pittsburg bed G, over the Mahoning sandstone and accompanied by its peculiar limestone and iron ore, are all so easily and readily distinguished that there can be no mistaking them. Confusion may arise in localities, owing to the split or separation of seams; but the main bed is always identical with its prototype, or the accompanying sandstones, limestones, or ores will always indicate the bed and its identity.

On the Great Kanawha the lower coals are perhaps in their maximum

size and best condition, and present a magnificent column of 14 seams and 50 feet of workable coal.

THE ALLEGHANY COAL-FIELD IN PENNSYLVANIA.

As before observed, this coal-field embraces 13,000 square miles in Pennsylvania, and extends through 24 counties. Of these, 13 counties are but partially in the coal-field, and several of them, as Lycoming and Sullivan, contain but a small portion. Eleven counties lie within the body of the coal-field, but only two of these contain the upper series, or Pittsburg coal. The chief mining localities are Barclay, near Towanda, in Bedford county, Blossburg, in Tioga county, Ralston, in Lycoming county, Bellefonte, in Clinton county, Johnstown, in Cambria county, and Pittsburg, in Alleghany county.

FIG. 119.

SECTION FROM THE ALLEGHANIES TO CHESTNUT RIDGE, NEAR THE MARYLAND LINE.

The above section, from Taylor's statistics, gives a correct representation of the main basins from the Alleghany escarpment to Chestnut Ridge, a distance of 30 miles. This section is north of the Frostburg basin, but taken near the Maryland line.

The following table embraces all the available data, and presents a pretty accurate estimate of all the coal mined in Pennsylvania from the Alleghany coal-field. The items marked with a star are official; those not so marked are approximate estimates.

TABLE OF BITUMINOUS COAL MINED IN THE ALLEGHANY COAL-FIELD IN PENNSYLVANIA, 1864.

	Tons.
*Barclay Coal & Railroad Company	54,000
Ralston and vicinity	20,000
*Blossburg	385,000
Lock Haven & Tyrone Railroad, &c	45,000
*On line of Philadelphia & Erie Railroad	27,000
*Connellsville & Pittsburg	146,000
*Pennsylvania Central Railroad	960,000
*Pennsylvania Canal	32,000
*Monongahela Navigation	1,170,000
On the line of the Youghiogheny	500,000
On the line of the Alleghany	500,000
Johnstown and vicinity	1,000,000
All other localities	1,000,000
Total tons of 2000 pounds	5,839,000

LOCATIONS OF THE CUMBERLAND MINES.

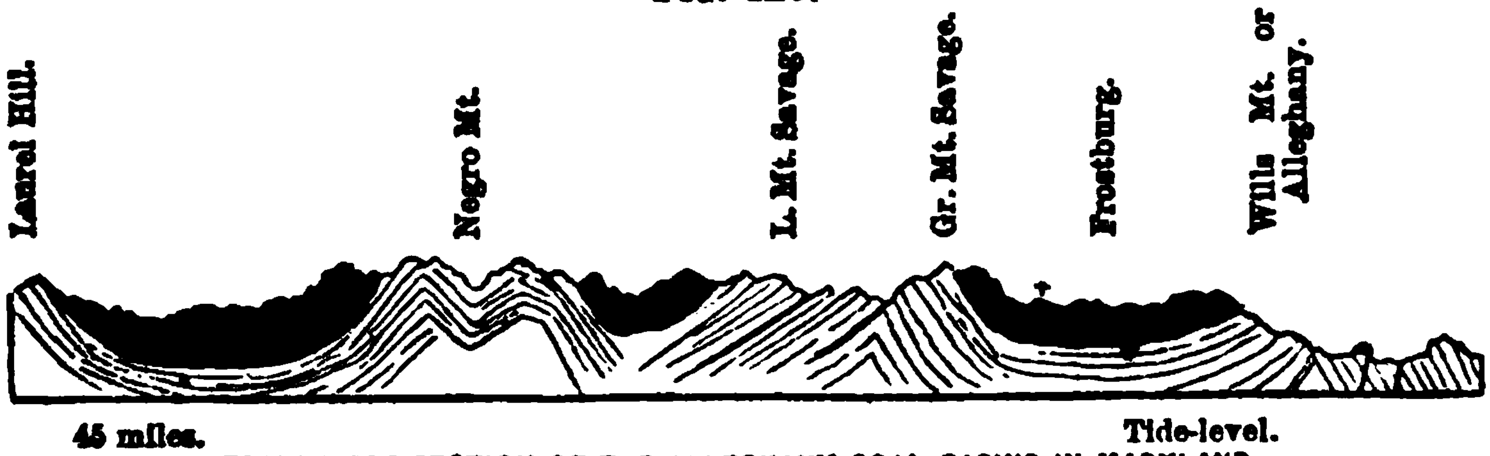
	No.		No.
Hampshire & Baltimore Coal Co....	1	Manchester Coal Company...........	15
Franklin Coal Company..............	2	Cumberland Coal & Iron Co......	16, 17
Preston Coal Company...............	3	Borden Mining Company.........	17, 18
American Coal Company.............	4	Midlothian Coal Company............	20
Swanton Coal Company...............	5	Bleanavon Coal Company............	21
Piedmont Coal Company..............	6	Astor Coal Company..................	22
Atlantic Coal Company...............	7	Consolidated Coal Company	23
Barton Coal Company.................	8	New Hope Mining Company.........	24
Potomac Coal Company...............	9	New York Coal Company............	25
Central Coal Company.................	10	Carbon Hill Coal Company...........	26
American Coal Company..............	11	Consolidated Coal Company..........	27
George's Creek Coal Company........	12	Ward Mining Company..............	28
Savage Mountain Coal Company....	13	Neff River Coal Company............	29
Consolidated Coal Company	14		

THE CUMBERLAND REGION.

The Cumberland coal-region in Maryland belongs properly to the Great Alleghany coal-field, though separated from the great body of that field by the high axis of the Negro Mountain, as shown by the accompanying map and sections. Most of the coal-mines in Maryland are in the Frostburg basin, denoted by the town of that name on the map.

The Cumberland coal-region, or that portion of the Alleghany coal-field known as the Frostburg basin, is about 5 miles wide by 30 miles long, or covers an area of 150 square miles: some accounts make it 180 square miles. That portion of the Maryland coal lying between the Savage Mountains and Negro Mountain, and extending across the State in a narrow trough, as represented by figure 120, contains about 130 square miles; and the trough or basin on the Youghiogheny, between Negro Mountain and Laurel Hill, or Briary Mountain, contains 250 square miles; making the total area of the Alleghany coal-field in Maryland about 550 square miles.

Fig. 120.



TRANSVERSE SECTION OF THE ALLEGHANY COAL-BASINS IN MARYLAND.

The erosion or denudation of the coal-strata in the Frostburg basin has been excessive. Of the 100,000 acres of coal-area in this basin only 20,000 are now estimated as containing the Big vein, or the upper large workable seam, and only 80,000 acres containing the lower workable bed, as the sections farther on will show.

The accompanying transverse section, figure 120, from Taylor's statistics, illustrates the connection of the Maryland with the Pennsylvania coal, as shown in figure 119. But that section did not embrace the Frostburg basin, as this (figure 120) does.

The Frostburg basin extends on the northeast into Pennsylvania, and on the southwest into Virginia. The distance through Maryland is about 20 miles. It is convex-shaped, or an oblong basin, rising slowly to the north and south, along the strike of the seams, from a common centre near the mouth of George's Creek, or its confluence with the Potomac, and more rapidly east and west, or to the outcrops of the seams, on the face of the Dan and Great Savage Mountains.

The rise of George's Creek from its mouth, near Piedmont, to its source, near Frostburg, is 1100 feet. But the rise of the seams which strike in the same direction is not proportionate to the rise of the streams. It will be noticed in figure 122 that the position of the Big vein is nearly 1000 feet above Piedmont, and yet considerably lower than the town of Frostburg. The longitudinal rise is, therefore, almost imperceptible, yet sufficient to affect the drainage of the mines or seams in the direction of the natural water-courses of the country. This is a fortunate coincidence, but one that is peculiar to all narrow basins in the Alleghany coal-field, with but few exceptions, and is in evidence that such basins have not been disturbed by an elevating or contracting process since their original formation, but that they were formed in basins having much the same form as the coal-basins now filling them. Sedimentary deposits in basins of moderate angles are uniform, and, consequently, the deeper portions of the basins successively preserve their basin-shape, as strata after strata are deposited therein. The drainage, therefore, naturally tends to the deepest points, and seek their outlets by the lowest or nearest gaps in the bounding mountains; or the accumulated waters burst their way towards the ocean through the soft mud barriers soon after the waters of the ancient inland sea found vent by the depression of its granite rim.

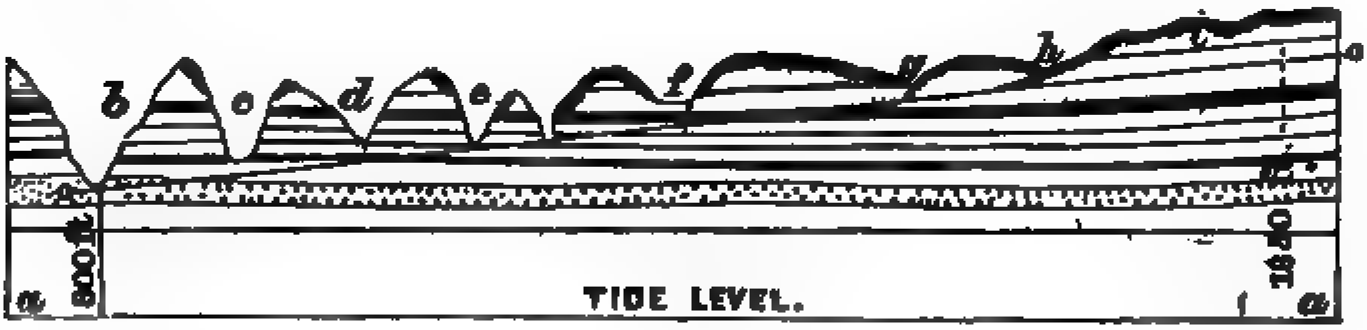
In figures 121 and 122 will be found a representation of the topography and erosion of the Frostburg basin. There are some who are disposed to grumble at the dispensations of Providence, and who would prefer to have a larger share of the "Big vein" than nature has allotted them; but such ungrateful creatures would not be satisfied even if this great bed lay unbroken from Virginia to Pennsylvania. We may consider every gorge or deep ravine that has been cut through the coal measures of the Alleghany coal-field as adits or levels to drain the coal-basins. Every stream, like George's Creek, which develops a rich basin saves more millions in shafts, machinery, and constant expenses of operation than we could now estimate. Were the Frostburg basin in the condition of the Newcastle coal-field in England,—as it would be were it not for the deep erosion of the streams,—

it would be almost inaccessible, under present circumstances. We think the frequent and deep erosions of our great coal-fields a fortunate occurrence,

TRANSVERSE SECTION, FROSTBURG BASIN.

a, a, level of the Potomac at the mouth of George's Creek; *b*, mouth of George's Creek; *A, B, C, D, E, F*, coal-seams; *o, o*, elevation. It will be noticed that George's Creek is the deepest part of the Frostburg basin.

FIG. 122.



LONGITUDINAL SECTION, FROSTBURG BASIN, FROM WESTERNPORT TO FROSTBURG.

Tide-level is represented by *a, a*; *b* is the mouth of George's Creek at Westernport; *c*, Mill River; *d*, Laurel Run; *e*, Koontz Run; *f*, Squirrel Neck Run; *g*, Wright's Run; *h*, Frostburg.

and one which will eventually exert a great economy in the development of the mineral wealth of our country.

These sections represent pretty fairly the entire Cumberland region, and show the seams in their relative position. The position of the seams, however, would be more correctly located in a vertical section, which we will endeavor to give if we can obtain reliable data in time. But figures 121 and 122 offer conclusive proof of the geological horizon of the Big vein, and its identity with our Mammoth bed in the anthracite regions. We have not yet been able to get the exact distances from the conglomerate to the great sandrock over the Mammoth, or the distances between the seams; but the position and order of the seams correspond precisely with the sections we have given in the anthracite regions. A is a small seam, and not considered workable; B is a seam of fair dimensions, averaging from 5 to 6 feet, and corresponds with the Buck Mountain; C is a small, unworkable seam, and occupies the place and partakes of the character of Gamma; D is a fair seam, corresponding to the Skidmore in the anthracite regions; and E is the "Big vein," and identical with the Mammoth.

STATISTICS OF THE CUMBERLAND COAL-TRADE,

FROM ITS COMMENCEMENT.

Compiled, from Official Sources, by C. Slack, Mount Savage, Md.

TABLE 1.—*Details of Year 1864.*

Name of Company.	1864.				Compared with 1863.	
	To B.&O.R.R.	To C.&O.Can.	Local.	Total.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
American Coal Co.	8,953	54,268	558	63,809	....	7,637
Central C. M. & M. Co.	19,677	39,864	8	59,549	9,068	....
Piedmont Coal & Iron Co.	21,428	834	....	22,262	....	9,299
Swanton Mining Co.	21,456	....	....	21,456	....	7,775
Potomac Coal Co.	26,060	....	....	26,060	651	....
George's Creek Coal & Iron Co.	41,644	....	1,565	43,209	7,759	....
Hampshire & Balt. Coal Co.	3,071	15,977	....	19,048	8,259	....
Neff Run Coal Co.	4,208	5,822	8,774	18,804	10,561	....
Frostburg Coal Co.	10,066	4,701	252	15,019	....	51,692
Consolidation Coal Co.	8,611	15,565	9,465	33,641	33,641	....
Borden Mining Co	14,862	38,022	216	53,100	....	31,560
New Hope Mines	9,296	13,982	5,709	28,987	....	8,309
Midlothian Coal Co.	3,109	5,085	93	8,287	8,229	....
Barton Coal Co.	7,111	....	....	7,111	989	....
George's Creek Mining Co.	20,721	....	....	20,721	492	....
Franklin Coal Co.	44,958	....	....	44,958	....	34,841
Atlantic & G. C. Co.	225	....	....	225	225	....
Cumberland Coal & Iron Co.	59,414	63,002	....	122,416	....	8,902
Blaen-Avon Coal Co.	7,831	1,520	....	9,351	....	18,941
Astor Coal Co	431	....	....	431	431	....
Hampshire & Balt. Coal Co.	44,552	....	....	44,552	8,302	....
	377,684	258,642	21,670	657,996	83,607	173,956
						83,607
					Total Decrease,	90,349

RECAPITULATION.

By Cumberland & Pennsylvania R. R. to Baltimore & Ohio R. R.	265,456 tons.		
" " " " to Canal	194,120 "		
" " " " to Local	21,670 "		
		481,246	
By Cumberland Coal & Iron Co.'s R. R. to Baltimore & Ohio R. R.	67,676		
" " " " " to Canal	64,522		
		132,198	
By Hampshire & Baltimore R. R. to Baltimore & Ohio R. R.		44,552	
Total 1864			657,996

Table 2.]

THE CUMBERLAND COAL-TRADE,

FROM 1842 TO 1864, INCLUSIVE,—23 YEARS.

Compiled, from Official Sources, by C. Slack, Esq., Mount Savage, Maryland.

	Frostburg Region.						Piedmont Region.				Total by Balt. & Ohio Railroad.	Total by Chesapeake & Ohio Can.	Aggregate.
	Cumberland & Pennsylvania Railroad.			Cumberland Coal & Iron Co.'s Railroad.			[illegible] Railroad.			Hamp. R. R.			
	By B. & O. R. R.	By C. & O. Can.	Total.	By B. & O. R. R.					Total.	By B. & O. R. R.			
	Tons.	Tons.	Tons.	Tons.					Tons.	Tons.	Tons.	Tons.	Tons.
1842.......	757	....	757	951					....	....	1,708	....	1,708
1843.......	3,661	....	3,661	6,421					....	....	10,082	....	10,082
1844.......	5,156	....	5,156	9,734					....	....	14,890	....	14,890
1845.......	13,738	....	13,738	10,915					....	....	24,653	....	24,653
1846.......	11,240	....	11,240	18,555					....	....	29,795	....	29,795
1847.......	20,615	....	20,615	32,325					....	....	52,940	....	52,940
1848.......	36,571	....	36,571	43,000					....	....	79,571	....	79,571
1849.......	68,676	....	68,676	73,773	....	73,773			....	....	142,449	....	142,449
1850.......	73,783	3,167	77,950	119,023	875	119,898			....	....	192,806	3,042	196,848
1851.......	70,893	51,488	122,381	103,808	81,540	185,348			....	....	174,701	82,978	257,679
1852.......	128,534	46,357	174,891	139,925	19,362	159,287	....	....	....	....	268,459	65,719	334,178
1853.......	150,381	84,060	234,441	155,278	70,535	225,813	70,560	3,165	73,725	....	376,219	157,760	533,979
1854.......	143,958	68,781	212,684	173,580	92,114	265,694	181,808	....	181,808	....	503,886	155,845	659,681
1855.......	93,961	77,095	171,056	97,710	100,691	198,401	221,245	6,000	227,246	65,570	478,486	183,786	662,272
1856.......	86,994	80,887	167,881	121,945	105,149	227,094	250,626	18,584	269,210	42,765	502,330	204,120	706,450
1857.......	80,743	55,174	135,917	88,578	54,000	142,578	244,968	7,400	252,368	51,628	465,912	116,574	582,486
1858.......	48,018	166,712	214,730	66,009	87,539	153,548	218,818	....	218,818	63,060	395,405	255,251	649,656
1859.......	48,415	211,639	260,054	72,423	86,203	158,626	257,740	....	257,740	47,984	426,512	297,842	724,354
1860.......	70,669	232,278	302,947	80,500	63,600	144,100	289,289	....	289,298	52,564	498,031	295,878	788,909
1861.......	23,873	68,308	92,181	25,983	29,296	55,279	85,554	....	85,554	30,660	164,196	105,478	269,674
1862.......	71,745	75,206	146,951	41,096	23,478	64,574	69,482	....	69,482	36,627	218,950	98,684	317,634
1863.......	117,796	173,269	291,065	111,087	48,523	164,610	266,480	....	266,480	36,240	531,553	216,792	748,345
1864.......	287,126	194,120	481,246	67,676	64,522	132,198	....	....	....	44,552	*399,354	258,642	657,996
	1,657,308	1,582,986	3,240,289	1,665,290	872,427	2,537,717	2,155,524	35,149	2,190,673	477,000	5,947,838	2,498,391	8,446,229

CHAPTER XVIII.

WEST VIRGINIA.

Area of Coal Formation in West Virginia—The Great Kanawha—The Coals of West Virginia—Salt-Wells and the Manufacture of Salt at the Kanawha Salines—Oil—Iron Ores—Sections of Formation—Identification of the Coal-Beds—The Great Kanawha Valley—Map—Description—Route of Great Freight-Line from East to West—Valley of Virginia—Region of Brown Hematites—Copper Region—Magnetic Iron Ores—Lead—The Gold Belt—Coal Oil from the Cannel Coal—Eastern Kentucky—Identification of the Coal-Beds—East Tennessee—Alabama—Ohio—Production of the Alleghany Coal-Field.

WEST VIRGINIA contains a larger portion of the Alleghany coal-field than any of the States enumerated through which it extends. Over 16,000 square miles of this great coal-field lie in Western and Eastern Virginia: of this area, however, only a few miles exist in Old Virginia, on the eastern edge of the field, in the southwest,—perhaps less than 150 square miles of available coal. But the best and most available portion of the Alleghany coal-field lies in West Virginia, and the greater portion of its vast area is naturally opened to development by the numerous streams which traverse its face from east to west.

The Great Kanawha River, running off at right angles from the Ohio, traverses the richest portions of the Great Alleghany coal-fields, cutting the coal measures of the region—2000 feet thick—to their base, and developing their exhaustless mineral treasures in the most available manner for practical production. But, after performing this most acceptable service to the future prosperity of the West, it renders the benefits conferred still more valuable, by dividing the otherwise impassable Appalachian chain at right angles, and taking the *nearest course* to the waters of the East, thus opening the most available route from the great rivers of the West to the seaports of the East, and connecting the minerals of the older geological formations—the iron, lead, copper, &c.—with the coal of the Alleghany.

The Kanawha region is still undeveloped, and the prize long sought by the dilatory Virginian slave-master is still to be accomplished by the enterprise of free labor. In no other portion of our country, North or South, are there more inviting prospects to labor, enterprise, and capital than is now presented in the Great Kanawha Valley. Not only its unlimited mineral resources invite attention, but the best portion of the trade of the great Mississippi Valley may be diverted into the channel of the Kanawha by ordinary means. To those who have observed the prodigious growth

of that trade, and the still superior proportions it must assume in the future, the questions we are discussing of this new route to the East will not be a matter of speculation, but of necessity. The routes now provided will not accommodate it, while the superior advantages offered by this route, in the hands of a free and enterprising people, cannot fail to attract attention. The *distance*, the *elevation*, the freedom from *ice*, and the constant supply of *water* from the mouth of the Kanawha, all present important and available advantages which cannot be overlooked.

DISTANCES FROM EAST TO WEST.

It will be noticed, by the table of distances given below, that the distance from the head of navigation on the Kanawha to the head of navigation on the James River, at Richmond, is 320 miles,—or thirty-six miles less by land than from Pittsburg to Philadelphia: with a saving in distance by water from Cincinnati, as a centre, of 200 miles. It is also sixty-three miles less by rail than the distance from Parkersburg to Baltimore, with about the same distance by water.

Table of Distances.

	Miles.
Charleston to New Orleans, by water	1847
Charleston to Cincinnati, "	269
Charleston to Point Pleasant, "	60
Charleston to Parkersburg, "	132
Charleston to Pittsburg, "	261
Charleston to Philadelphia *via* Pittsburg	617
Charleston to Baltimore *via* Parkersburg	515
Charleston to Richmond, Virginia, *via* Covington & Ohio Railroad	320
Charleston to Richmond, Virginia, *via* "Central"	351
Cincinnati to Philadelphia *via* Pittsburg	816
Cincinnati to Baltimore *via* Parkersburg	671
Cincinnati to Richmond *via* Charleston and Covington	589
Cincinnati to Richmond *via* Charleston & Central	610

THE COALS OF THE GREAT KANAWHA REGION,

As we shall specially describe, are of various constituencies, and are adaptable to all the requirements of the trades and manufactures. The *hard* and *caking*, with the fat and gaseous bituminous, the variable splint, and the rich and oily cannel, are all found in the same mountains, and are all accessible to the miner and to navigation, through the agencies of the eroding waters, which have exposed coal in a thousand places.

The avenues to markets afford the cheapest and most available transportation on navigable rivers; while the markets themselves are unlimited in extent, and rapidly increasing their consumption.

The whole valley of the Mississippi is open beyond controlling competition to the trade and the production of this region, while the present avenues to the East and the commerce of the world are but little less available than from the older and more developed centres, with *this* advantage ever open to the Kanawha region,—that a route may be constructed having every advantage over the most favorable avenues of trade now open from the East to the West.

This is, therefore, the *natural mining* and *manufacturing centre* not only of West Virginia, but of the Great Alleghany coal-field; and had the Virginians any share of free enterprise and energy, Charleston would long ago have been a formidable rival to Pittsburg.

Looking to the natural results of location and availability, now that this magnificent region is open to free labor and a corresponding development, we may anticipate for Charleston the dignity of the State capital at no very distant day, or, what may be better, the metropolis of the mining and manufacturing interests of the West.

Coal River, Elk River, and Gauley diverge from the Great Kanawha and spread their branches over one of the richest and most magnificent coal-regions in the world, and bring down their wealth to one common centre on the Great Kanawha; or such might and may be the result under future developments.

The coals of this region, generally, are better, purer, and more available for all the requirements of trade and manufacture than the coals of any other portion of the Alleghany coal-field. The seams of coal are more numerous and their thickness greater than in any other portion of this coal-field; it can be mined cheaper and with more economy generally, under the same rates of labor, than in any other region in this country without exception. The markets of the West, or the great Ohio and Mississippi Valleys, are open beyond any controlling competition to the trade of the Kanawha in *coal, oil, salt, iron,* and *lumber*. Charleston is 200 miles nearer Cincinnati than Pittsburg, and always open to navigation; while the Ohio to Pittsburg is frequently closed by ice in the winter and interrupted by low water in the summer. The principal volume of the great and rapidly increasing trade of the West may be diverted to the seaports of the East, *via* the Kanawha Valley, with much economy in time and transporting power.

We do not make these remarks as invidious comparisons. Nothing we can say will detract from Pittsburg; nor do we wish to say one word against that noble city and her vast resources. We only wish we could say to the helpless, dilatory Virginians, "Go ye and do likewise;" and we would willingly show them the way.

The geological reports on the coals of West Virginia make the number of workable seams to be 13; but 14 have been developed on the dividing

ridge between the waters of the Great Kanawha and Coal Rivers, on a line with Lenn's Creek, and in all probability these are all below the Pittsburg seam. But here every seam appears to have reached a maximum size for the bituminous formations. While B and E are not as large as found in a few other localities, the intervening seams, which in other portions of the field are of no commercial or workable value, are here found in workable size, or from 2 to 3 feet in diameter. The number of workable seams are greater than those found within the same measures in Pennsylvania any place, not excepting the anthracite fields, though the total amount of coal is less than that which is found at many points in the anthracite regions. But were we to count all the seams, both small and large, in the western part of the anthracite measures, they would correspond nearly with the coal-seams found on the Great Kanawha. We have stated our belief, however, that the cannel coal-seams have no counterpart in the anthracite regions,—that they appear within the rich bituminous shale, which does not exist in the Eastern measures; and, consequently, three of the numerous seams in the Kanawha section are thus accounted for.

We may also here notice a fact which may be interesting, and which may have some connection with the divisions of the seams in this locality, or *vice versâ*.

It will be found farther on that the coal measures in Western Kentucky, and in the same general geological range or position in the great basin with the Kanawha, are in like manner divided and represented by numerous small seams instead of a few large ones, as in some portions of the anthracite regions, where the coal measures reach the same elevation.

The seams which we give in the following table exist, we have reason to believe, under the Pittsburg seam, and do not, therefore, represent all the productive coal measures of West Virginia. There are still several seams found in the higher grounds back from the river, or on the head-waters of Elk, Coal, Gauley, and other large streams emptying into the Great Kanawha; also on the Little Kanawha, Guyandotte, Big Sandy, &c. Yet we have not found the same productive condition in any other part of the Great Alleghany coal-field as compared with the measures between Coal and Kanawha Rivers. The thickness of the strata is estimated in this table, but the seams have been practically developed.

A short distance above the conglomerate a small seam exists, not considered workable. But about fifty feet from the conglomerate a variable seam is found, ranging from five to ten feet in thickness: this coal in all probability lies below the level of Lenn's Creek, at the forks, and is not found above *water-level*. Above this exists the large seam of iron ore to be noticed farther on. The third seam of coal appears to be small, but varies from two to four feet. The fourth is a cannel coal of about four feet, but varies from three to six feet. The fifth seam is a

hard bituminous, ranging from two to four feet in thickness. The sixth is likewise bituminous, but not generally over three or four feet thick, and is sometimes smaller. The seventh seam, sometimes cannel coal, ranges from three to five feet thick. The eighth and ninth are hard, bituminous seams, from thirty inches to four feet thick. The tenth seam is generally large, ranging from seven to ten feet, but is divided by fire-clay, which sometimes, in practical effect, makes two workable seams of the one. The eleventh is a fine cannel seam, known as the "Peytona" (?) cannel, five to six feet thick. The twelfth, thirteenth, and fourteenth are not opened or developed, but, from appearances, are known to be seams of good workable dimensions, and one of them is supposed to be cannel. The average dimensions of the seams and the thickness of the intervening strata are about as given in the accompanying table:

DIMENSIONS OF SEAMS AND THICKNESS OF STRATA ON THE LAND BETWEEN KANAWHA AND COAL RIVERS.*

			Feet.	Feet.	
A	No.	1, coal on the conglomerate	30	2	A
B	"	2, coal and intervening measures	50	6	B
B	"	3, coal and " "	100	3	B
	"	4, coal cannel " "	90	5	
C	"	5, coal " "	95	3	C
C	"	6, coal	80	2½	C
	"	7, coal sometimes cannel "	100	3	
D	"	8, coal " " "	85	2	D
E	"	9, coal " " "	90	2½	E
E	"	10, coal " " "	50	10	E
	"	11, coal cannel " "	100	6	
F	"	12, coal " "	100	4	F
?	"	13, coal cannel? " "	195	5?	
?	"	14, coal " "	80	3?	
		Coal measures	1250 coal	50	

THE GREAT KANAWHA AS A MINING AND MANUFACTURING REGION.

We do not propose in this connection to devote much space to the consideration of salt, oil, or iron ore separate from their connection with coal; but we wish to call especial attention to this magnificent region, which has been so long overlooked or neglected by capital and enterprise,—locked up as it were by the evil genius of the slave-power.

The salines of the Great Kanawha have been celebrated and productive

* The thickness of the measures is perhaps exaggerated, as they are only estimates. The coal-seams, however, are actual developments as far as No. 11.

for a period of fifty years; and, though the brine is not so dense or saturated with salt as the production of many of our best salines, the availability and cheapness of the material and means of evaporation render the economy of manufacturing more favorable than that of most salines, and, we should infer, equal to the best.

Take one instance,—which will cover all; for the same means are available to all. A salt-well is bored to the salt-strata and through the upper or heavy oils, and carefully tubed to the brine. The well is then bored from 500 to 1000 feet deeper, until the gas of the second or light oils is struck, as shown by figure 000 under the head of Petroleum. Sometimes this gas exists in such a state of tension that, on being tapped, it bursts forth with the violence of gunpowder. But this violence is soon blown off, and the gas continues to flow with considerable force, or with force enough to blow the brine up the tube and into the salt-works, and then, passing on to the fire, under the evaporating furnaces, is there used as fuel instead of coal. The gas thus pumps the brine into the tanks and evaporates it in the kettles. With proper fixtures and mechanical arrangements, the cost of producing salt under such circumstances would be merely nominal. We cannot see how any other mode could be more economical: even if solar evaporation be used, the cost of pumping is saved.

Our remarks on the oil or petroleum of this region will be reserved for a more appropriate place in another chapter. We may state, however, that the region of gas above mentioned lies immediately over the great reservoirs of oil which have been so productive in Pennsylvania and on the Little Kanawha in this State.

IRON ORES.

Though this subject also belongs appropriately to another part of this book, we feel justified in noticing it here, since this region is a *terra incognita* to the iron-master.

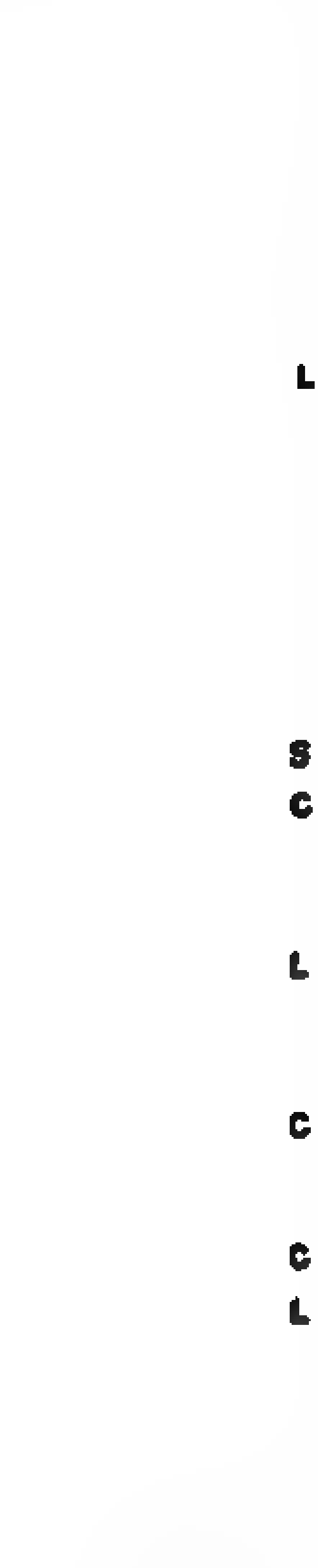
FIG. 123.

TRANSVERSE SECTION GREAT KANAWHA VALLEY, FROM ELK RIVER A, TO COAL RIVER C, ABOVE CHARLESTON.

Two prominent seams of iron ore exist,—one as shown by figure 124, on its proper geological level over B, as found and worked at Johnstown,

Cambria county, Pennsylvania, and which exist in variable quality and quantity wherever this seam of coal exists. In some places it is rich and productive, while in others it is lean and worthless. Here, however, it appears at the surface as a brown oxide of great richness, yielding 60 per cent. of metal in the furnace; but the bed is naturally a calcareous ore, where not oxidized, yielding here from 40 to 45 per cent. of metallic iron. Its size is from 3 to 4 feet when in its best condition, accompanied, however, by leaner shales or argillaceous ores. The second seam of ore is generally argillaceous and not very rich. Its proper position is between E and D, and near the Freeport or Curlew limestone, which underlies the lower bench or bed of E. In the anthracite regions .. immediately underlies the Mammoth; but, as we have several times stated, the Mammoth divides, in its westward spread, and forms several seams in the bituminous regions.

FIG. 124.



VERTICAL SECTION ON LENN'S CREEK, KANAWHA.

Figure 123 represents the general form or topography of the valley from Elk River on the north, at *a*, to Coal River on the south, at *c*. While this is a transverse section of the valley, it is through a longitudinal portion of the Great Alleghany coal-field. The figure gives an approximate representation of the main strata; but a more comprehensive and systematic detail is given in figure 124 of the coal measures. But in vertical section, figure 189, under the head of Petroleum, will be found the order of succession in which the oil, salt, and coal exist in this valley.

In figure 124 we give the approximate places of the coal-seams, iron ores, and principal limestones. It will be found to differ slightly from the generalized section representing the coal measures of the Alleghany field, but the difference simply exists in a greater number of seams, or the enlargement of seams which are generally too small to be enumerated.

In figure 124 the letter C represents cannel coal, L limestone, and S Mahoning sandstone. The dotted lines represent iron ore. The distances are approximate from seam to seam, but the general position of the principal seams is very near their proper geological horizon; while the limestones, iron ores, and sandstones identify them with their cotemporaries in other sections.

G, or the Pittsburg seam, does not exist on the river hills, as may be

seen in figure 123, but is found on the higher mountains back from the river. This seam is smaller than our representation makes it, and seldom produces over four or five feet of merchantable coal in this region. E is a double bed, divided by about twelve inches of fire-clay, and B is also sometimes found divided in the same manner by fire-clay. Its size is less, generally, than that of E, and more variable, ranging from 4 to 10, and sometimes even 20, feet in thickness. But when such great enlargements take place, several of the smaller accompanying seams are merged in the main body, or only separated by comparatively thin slates or fire-clay partings. When this seam is in its best condition, it is very productive and worked with much economy. With rare exceptions, it is the best furnace coal in the Alleghany field, and whether worked for such a purpose at Blossburg, or Johnstown in Pennsylvania, or elsewhere, it always produces a hard, dense coal in which the carbon predominates. But here, according to a natural law which we have before described and accounted for, the coal of all the seams contains more bitumen, and consequently less carbon, than at the localities named, or, in fact, any point east and north. Some of the small seams between B and E also produce good furnace coals. But their quality for such purpose seems to increase towards the head of the Kanawha, or above Gauley, since the carbon increases and the bitumen decreases in that direction, but, we must say, to some extent at the expense of purity. There are but few places, if any, where the coal of the Alleghanies is better in quality and quantity than in a line with the section given in figure 123.

The cannel coal-seams are marked on the side of figure 124 C, and are not enumerated, as the common bituminous seams are, alphabetically, because we find no equivalent for these cannel seams in the anthracite regions to which our nomenclature applies particularly.

We are not certain, however, that this conclusion is correct. The first regular cannel seam is found above B, and cannot be a "split" of that seam, since the fossiliferous limestone and calcareous ore intervene. It may possibly be identical with C; and the small seams found above it, and that which we have designated as C in figure 124, may be mere enlargements of the numerous coal-strata, which are too insignificant to obtain attention in other localities. But whether the cannel coal between B and C be part of C, or a peculiar production of the bituminous regions, it does not invalidate our identification of the principal seams, since they occur in such systematic order and are accompanied by such unmistakable associates that their peculiar characteristics are always prominent.

In order to present some of the advantages of the Great Kanawha Valley as a mining and manufacturing locality, and its availabilities for trade and transportation, we give a small map of the Great Kanawha Valley and its resources of iron ores.

MAP OF THE GREAT KANAWHA VALLEY AND THE IRON REGIONS AT THE HEAD OF THE NEW RIVER.—SCALE, FIFTY MILES TO AN INCH.

DESCRIPTION OF MAP.

The Great Kanawha is known by this name to the mouth of Gauley; above that, it is known as the New River, which takes its rise among the mountains of North Carolina.

No. 1 is Guyandotte, at the mouth of the Guyandotte River, and is the proposed terminus of the Covington & Ohio Railroad. No. 2 is the location of Charleston, at the mouth of Elk River. No. 3 is the site of Kanawha City,—a comparatively new place,—at the mouth of Lenn's Creek and on the proposed railroad to Peytona, on Coal River. No. 4 is the mouth of Gauley River, and No. 5 the mouth of Greenbrier River. At this point the Covington & Ohio Railroad enters the valley of the New River. The grading of this road is partially completed. A short distance farther up, at 6, is the mouth of Sinking Creek, the most available proposed route of a great freight-line from the East to the West, leaving the New River and crossing over to the James. It is anticipated that the maximum grades of this route will be only 20 *feet to the mile*, and the distance from the navigable waters of the West to tide-water considerably diminished over the most favorable routes now existing.

No. 7 is the Great Limestone Valley, known through Virginia as the Valley of Virginia. It stretches from the cane-brakes of Alabama to the Valley of the Hudson and beyond. It is narrow a short distance east of this point, on the high water-shed between the James and the New Rivers; but at "Central City" (8) and farther west it widens out in rich and extensive plains, and forms some of the finest plantations or agricultural lands in Virginia. It is really a delightful region, and destined at no distant day to become one of the most populous and wealthy districts of the South.

No. 9 is the location of Wentworth, in North Carolina, between Danville and Greensboro (10), and No. 11 is the position of Raleigh.

The dark spots at 13 represent the great region of magnetic iron ores; while 12 represents the gold-belt. 14 is the rich copper region in Southwestern Virginia, and 15 is the region of brown hematites on each side of the great valley. 16 is the Alleghany range.

This region of iron ores will perhaps rival any locality in our country—Iron Mountain, Pilot Knob, or Lake Superior not excepted—either in quality or quantity. There is no limit to the resources of brown hematite in this section. It exists in massive beds of great extent, and ranges through a vast area of country. We have seen beds of ore in this region equal to the celebrated Cornwall deposits, and can state, from practical experience, there is no richer or purer iron ore of this description to be found. The miniature map shows the coal of the Kanawha to be in close proximity to this great region of iron, and connected by a large river, which levels as it were the mountains and grades a uniform path through the huge Alleghanies. From the Ohio River to the boundary of North Carolina the ascent is easy and uniform, and the elevation moderate. The point at which the dividing ridge between the waters of Virginia and North Carolina may be pierced by tunnel is not over 2500 feet above tide, and only 2000 feet above the Ohio; while the distance is about 250 miles, or a common grade of less than 10 feet to the mile. But, as the upper portions of the distance overcome the most elevation, the grades at the summit would be 50 feet to the mile for a short distance. This, however, would have no reference to the rich hematitic iron region of the valley. These ores may be reached at a maximum grade of 20 feet to the mile, with a common descending grade from the ore deposits to the coal of the Kanawha.

From the magnetic iron regions of North Carolina the grades would be adverse for a short distance to the summit. But the great richness of the ores—which yield about 70 per cent. of metallic iron in the charcoal-furnace—would compensate for additional freight or transportation. The railroad line thus suggested from the Ohio to the great iron and copper regions of Southwestern Virginia and North Carolina not only give the valley of the Kanawha an abundant supply of the richest and purest iron ores and open out a splendid mineral and agricultural region, but also open direct communication between Virginia, North Carolina, and the Great West, and, we hope, at no distant day, the golden gates of the far Pacific.

At No. 5 the Greenbrier River joins the New River; and here the projected and partially finished Covington & Ohio Railroad enters the valley of the Great Kanawha. This line connects at Covington with the Virginia Central Railroad, which centres at Richmond. By this line the distance from tide to the navigable waters of the West is less than by any other route, and the grades are more favorable. But farther up the New

River, at No. 6, is the mouth of Sinking Creek; and at this point a means of communication exists from the waters of the West to those of the East, which has been long and singularly overlooked. The mountain-ranges here run parallel from the New River to the James, and their valleys afford the *lowest* point of elevation from the Eastern to the Western waters. The Great Alleghany ranges are cut down to their base by the waters of the New River, while the waters of the James drain its eastern escarpment. The deep valleys of the east cross the courses of these rivers: consequently, a line from river to river along the valleys must have less elevation to overcome than a line across the summit of the Alleghanies. The writer examined this line in 1858–59, and, by barometrical observation, found that the elevation to be overcome was nearly 1100 feet less than the most favorable present route from east to west; or the greatest elevation is less than 1400 feet where the denuding ridge or water-shed may be pierced by tunnel.

This route offers to Eastern and Western Virginia natural advantages which no other route from east to west can possess. It presents a line whose maximum grades shall not exceed 20 feet per mile, and whose distance from Richmond or City Point to navigable water on the Kanawha is only about 320 miles.

These natural advantages are so important and desirable not only for the development of the region in question, but all the great West, that they must and will force themselves on the attention of the enterprising and far-seeing. The consummation of such a desirable object would lift Virginia from her present ruin and desolation and place her fairly and advantageously in emulation with the progressive Northern and Western States. It would be more effective in eradicating sectional prejudices and strife than provost-marshals or bayonets, lecture or sermon; it would teach our "erring sisters" the way to wealth, power, and prosperity, and show them that all they sought by war and separation exists in peace and union.

Under such circumstances, the Great Kanawha Valley assumes an importance not hitherto noticed or discussed since the days of Washington, who first called attention to this subject and projected and predicted what the present writer now only reiterates.

In order to obtain approximately the coal production of the Western bituminous coal-fields, we shall be forced to estimate roughly the amount of coal mined in each State. It will be impossible to obtain at this writing the correct figures; but we shall not be far wrong if we place the amount of coal produced at a half-million tons annually in West Virginia, on the line of the Ohio, and in the Kanawha Valley. By far the greatest quantity of the coal used by the Western steamers, and in the cities on the

Ohio, is mined in Pennsylvania, though the coals of West Virginia are more accessible and may be supplied with more economy.

COAL OIL.

The manufacture of coal oil from the rich cannel coal of the Kanawha was extensively carried on in that region before the war, and practical men who know the cost and have calculated the profits by experience state that, as a general rule, more money may be made in manufacturing this oil from the coal than by boring for it and obtaining it in a natural state. The one is certain and continuous, while the other is uncertain and precarious. The first depends on skill and capital; the second, on a fortunate "strike,"—which, unfortunately, is not the rule, but the exception: far more blanks than prizes are drawn from oil-wells.

But when the manufacturing of oil from coal is conducted with the proper skill and judgment, the results are certain. And in no place can this be done with more success than in the Great Kanawha Valley, because in no other locality are there richer coals or a more abundant supply, while timber for barrels and other accessory means are abundant and available.

The best cannel coal, when properly treated on the large scale, will yield 60 gallons of crude oil to the ton; and the cost of the mining and manipulation ought not to exceed $2.50 per ton,—which, at even 10 cents per gallon in the tanks, would leave a large profit on the oil produced.

There is great improvement to be made in the manufacture of coal oil from the coal, and the cost of producing it may be reduced nearly one-half from the present estimates, which is from 25 to 30 cents per gallon for refined oil. We have noticed, particularly, several large items of expense in the production of the crude article which may be abated, but which in this connection we shall not discuss: it belongs properly to the department of Petroleum, which will be found in another part of this work.

It will thus appear that the Great Kanawha Valley is not only a great natural mining and manufacturing region, but one that may enjoy the greatest trade that ever flowed from the mountains or the inland plains and valleys to the sea. The coal, iron, oil, and salt of this region are inexhaustible, and may be produced with the minimum of labor and expense, and, consequently, the maximum of profits.

We have long beheld the vast mineral resources of this part of the Great Alleghany coal-field with professional admiration, and have frequently called attention to their value. If we now *seem* partial to West Virginia, we can prove that our affections have always turned towards her unlimited stores of coal and iron with an ardent desire to be able to pronounce the "open sesame" which should expose her treasures to the world.

THE ALLEGHANY COAL-FIELD IN KENTUCKY.

We shall briefly present a few of the leading features of this portion of the great coal-field, since it is but little developed, and presents but few points of special interest, where the coal is intersected by navigable rivers, since it lies near the head of the streams. Its margin, of course, on the north lies along the Ohio; but we think the Big Sandy and the Cumberland are the only navigable waters which intersect it. The Big Sandy runs its full length over or among coal-beds, but only the upper waters of the Cumberland, which are seldom navigable, reach this coal-field. None of the Kentucky railroads penetrate its almost unbroken area, except a short branch at Ironton on the Ohio. The coal-area occupies all or part of twenty counties in Eastern Kentucky, and embraces an extent of 10,000 square miles. The western margin of the field enters Kentucky near Portsmouth on the Ohio, and leaves it near Monticello, a short distance below and east of which it crosses into Tennessee, the general course being southwest.

The Big Sandy is navigable through Eastern Kentucky a distance of 100 miles when the streams are high, and the coal is found either below or above water-level the whole distance. Below and in the vicinity of Louisa, at the confluence of the Tug Fork of Big Sandy, most of the coal lies below the bed of the river, but farther up it commences to rise above the river, and the seams of coal which may lie one hundred feet deep at Louisa are five hundred feet above the river at the Russell Fork. The dip is therefore general and gradual from the east to the west until the Ohio is reached, and from thence it is reversed and from the west to the east. Some distance above Prestonburg considerable coal was mined before the war, the coal being floated down in barges during high water. The localities of the mines in this section are about half-way up the sides of the mountains, and, we should judge, below the Mahoning sandstone.

From a hasty and necessarily brief examination during the year 1864, when this region of country lay between the lines of the Rebel and Union armies, and when guerrillas had full sway, we concluded the large seam worked on the Louisa Fork of Big Sandy to be identical with the cannel coal over E, since the Mahoning sandstone seemed to lie above. The coal produced was excellent, and contained about 60 per cent. of bitumen.

Section of Coal Strata on the Louisa Fork of Big Sandy above Prestonburg.

	Ft.
Conglomerate (commencing at the base)	20
Coal, A	3
Conglomerate, sandstones and slates	80
Coal, B	6
Sandstones and shales	90
Coal, cannel	5
Slates and shales	60
Coal, small	2
Sandstones, &c.	100

	Ft.
Coal, C	3
Sandstones, shales, &c	100
Coal, D	4
Sandstones, &c	100
Coal, E	5
Slates, fire-clay, &c	30
Coal, E	4
Slates, shales	100
Coal, cannel	6
Slates, shales, &c	50
Mahoning sandstone	90
Coal, 38	858

The above corresponds very nearly with the Kanawha section, and is almost identical with a section taken on the Tug Fork of Big Sandy in the Kentucky Geological Survey. Coal E is there wanting; but the space evidently admits of its existence, and we must conclude the error to be with the survey and not in the measures. The evidence of regularity and uniformity in the coal-seams of this field is too great to be doubted.

Our exploration of this portion is too limited to enable us to locate the iron ores and limestones which accompany the principal seams; but the short investigation we were able to make left no doubt on our mind that they existed in "place" and in order on the same geological horizon with the measures of Virginia and Pennsylvania.

The amount of coal mined in Eastern Kentucky may have amounted to 300,000 tons per annum before the war. We may safely put it, however, as low as 250,000; though since and during the war but a very small portion of that amount has been mined. Nothing has been done on Big Sandy, and but little if any mining has been done on the Cumberland in Eastern Kentucky during the war.

THE ALLEGHANY COAL-FIELD IN TENNESSEE.

The geological reports of the coal formations of East Tennessee are useless for all practical purposes; and, as but little development has been made in mining operations, we are left to our limited knowledge of the region in question for available data.

The coal measures are confined to a narrow boundary, and occupy the high mountain-plateaus which terminate abruptly on the east, above the escarpments of the huge Cumberland Mountains,—a continuation of the Alleghanies,—and are cut off with almost equal abruptness by erosion to the west. The eastern margin of the coal-field is parallel with the mountain-formation, and comparatively uniform, but the western edges are exceedingly irregular and zigzag in their course, which, however, is generally in a southwestern direction and a continuation of the line through Eastern Kentucky.

The coal-area of Tennessee is about 3700 square miles; but most of it lies in an inaccessible mountain-region, which for a long period must remain undeveloped, while the more available districts supply the wants

of the Mississippi Valley as far as fuel is concerned; and the same remarks may apply with equal force to a large portion of Eastern Kentucky. But there are several points where the coals of East Tennessee are available for home-consumption, and to a certain extent for the Eastern markets in North and Middle Georgia.

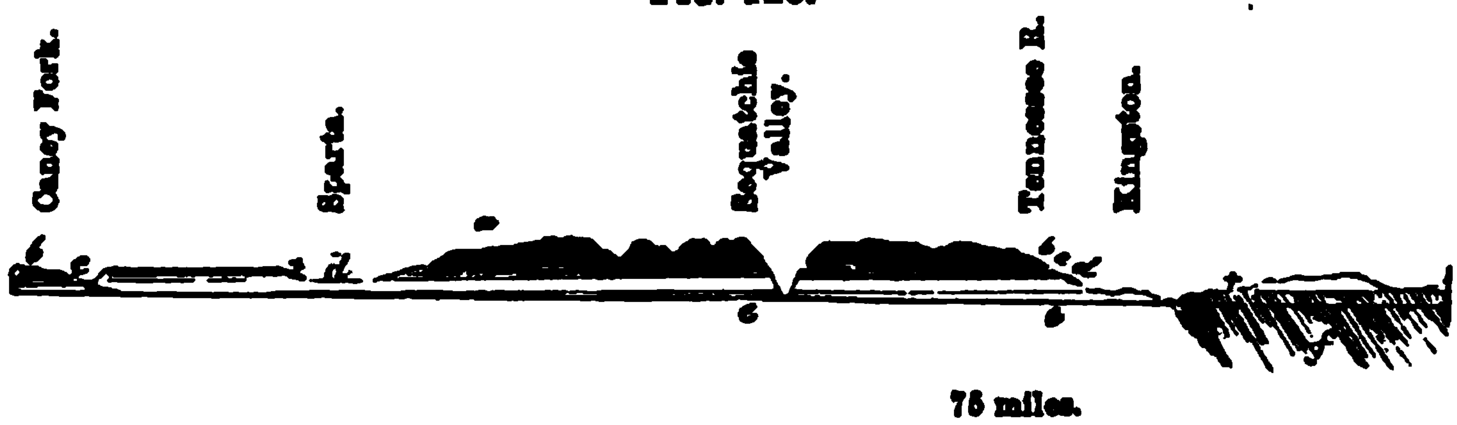
Chattanooga and vicinity may become a great manufacturing district, since the coal is plentiful and accessible in this locality and iron ore is abundant and rich. Before and during the war, until the evacuation of this great strategic point by the rebels, a large quantity of coal was shipped from this place to Rome, Atlanta, and other places in Georgia, for the use of the rolling-mills and foundries employed in furnishing munitions of war for the rebel armies.

There was also a large amount of pig-iron made here, and several furnaces were successfully in blast, turning out good coke-iron. But after the occupation of Chattanooga by the Union forces the rolling-mills of Georgia were forced to suspend, for want of coal, since there was no other source of supply except a small and undeveloped body of coal on the Coosa River in Alabama, some 40 or 50 miles below Rome.

The Chattanooga mines were located about 14 miles from the town, on the summit of the Lookout Mountain. They were connected with the place by a railroad up Wills Valley, or, we believe, a continuation of that valley, through which flows the Chattanooga Creek. Coal B is the only productive seam in this region, though C and perhaps D may form in the centre of the long depressions which now hold the coal on the tops of the mountains. It ranges from 4 to 10 feet in thickness.

The next prominent point where coal is mined to any extent is nearly opposite Kingston, on the Tennessee River. Here the river runs close along the foot of the Cumberland Mountains, and the coal is obtained from their summits. It is also mined on the Cumberland River, and at several points on the Tennessee River below Chattanooga, for home-consumption and use in the furnaces. The usual coal production of Tennessee may be set down at 500,000 tons per annum. We have not been able to obtain any correct sections of the coal on the Cumberland Mountains, but can state that all the available coal must exist in the four lower seams, A, B, C, and D. E does not exist, on account of the limited thickness of the measures. B is the chief productive seam; its size is, as usual, variable, and ranges from 4 to 20 feet. The following transverse section, from Taylor, gives a slight impression of the form and character of the coal measures in Tennessee. It is very minute in scale, and conveys no idea of the great elevation at which the coal exists on the huge Cumberland Mountains, which tower a thousand feet above the valleys at their base. From this elevation the coal must descend to transportation on the Tennessee River, since all the coal of this region exists on the mountain-tops.

Fig. 125.



a, coal measures; *b*, sandstone with iron ores; *c*, bituminous shale; *d*, Carboniferous limestone; *e*, old red sandstone; *f*, upper Silurian.

The Silurian rocks mentioned at *f* are tilted or inverted by the sharp axes of the folded gneissic strata which form the overlying Silurian and Devonian in long, narrow and steep troughs and ridges to the east of the Cumberland Mountains, as the same strata are folded to the northeast in the anthracite fields and intermediately.

ALLEGHANY COAL-FIELD IN ALABAMA.

That portion of the Alleghany coal-field in Alabama covers 4300 square miles of superficial area, and forms the southern extremity of the field. Its form is peculiar, as shown by the accompanying map, which is condensed, with some alterations, from the Alabama State Survey by Prof. Tuomey, and forms the knob on the handle of the great club which the Alleghany coal-field represents on paper, as the map of Italy takes the form of a boot under the same representation.

The end of the formation proper would appear to terminate with the high terminal points of the Lookout and Sand Mountains; but the evidence is unmistakable of a sudden depression of the great mountain-ranges and a corresponding depression of the superincumbent coal strata. The connection has also been found to be almost continuous between the coal measures, and the accompanying millstone grit and Carboniferous limestones occupy, geologically, the same horizon, or order of stratification, which we find general in this coal-field.

We might be led to suppose, from Professor Tuomey's report, that the limestones and coal measures were stratified unconformably upon the Silurian formations; but such is not the case. We investigated this subject fully during a late visit to Alabama, and found the same general contraction prevalent in the Eastern Palæozoic and Azoic formations which we find so general on the eastern border of the great basin. The eastern strata are here folded sharply against the gigantic sides of the Lookout Mountain; but the strata in that mountain-range and that on which they rest are conformable to the coal measures, and not unconformable, as represented in Taylor's statistics, and as copied from Professor Tuomey's reports.

The Coosa, Cahawba, or St. Clair coal-field, as it has been variously

called, seems to be part of the same great field. But this portion has been depressed to a greater extent than the more western basins, and slightly folded in basin-shape by the lateral contraction which folded the parallel Silurian strata to the east.

The gradual thinning or depreciation of the Palæozoic strata in this direction, though not so rapid as it is westward from the point of its greatest thickness in Pennsylvania, has still so diminished the strata intervening between the coal and the Great Valley limestone No. 11, that the Carboniferous lime and this—the Auroral lime—are brought almost into contact, compared with their vast distance apart in the northeast.

DESCRIPTION OF THE MAP.

The upper, or northern, end of the St. Clair, or Coosa, coal-field is near Gadsden, on the Coosa River. There appears to be no immediate connection between this isolated coal deposit and the larger area to the west, or the coal of Lookout Mountain to the north. But there is an evident depression of the great Lookout range to the south, carrying the coal down with it. The seams on the northeast of this deposit are extremely thin, seldom over 18 inches thick, but very pure and clean. We should take the only seam we saw open, and the only one that appeared to exist at its northern extremity, to be A, or the lowest coal in the field. But about 30 miles farther to the south, nearly opposite Talladega, the next upper seam, B, is found; and farther south a "split" of B, or the next seam, C, exists.

A never gets over 3 or 4 feet thick in the Alleghany coal-field, but B is sometimes 20 feet in thickness. Here it is about 5 feet when in its best condition; but farther south, on Broken Arrow Creek, and at Montevallo, it increases to 10 feet,—at the expense, however, of its purity. In St. Clair county, and particularly the mines on Trout Creek, the coal of B is excellent, containing about 30 per cent. of bitumen, and coking readily. It forms a hard, pure, and silvery coke, of the best description for the blast-furnace or cupola.

The seam, where worked by Raglan & Co., on Trout Creek, nearly opposite Talladega, and 20 miles to the west of that place, was about five feet thick at the time of our last visit to this region. It was worked by a shallow shaft near the outcrops of the seam, and both water and coal were brought up by horse-power. The work was conducted on the most primitive order and in the most costly manner; while the coal was hauled 20 miles in wagons, over the worst of mud roads, to the railroad at Talladega, or hauled to the Coosa, and then floated in arks down that rapid and dangerous river to Montgomery, some 160 miles distant. Generally, about two out of every three of these arks got safely through. Yet on this precarious supply did the foundries of Montgomery depend, since the coal of

THE ALLEGHANY COAL-FIELD IN ALABAMA.

Montevallo, which went by rail to Selma, is not fit for smelting purposes. In fact, it is the worst coal to be used as a fuel that we ever saw, and contained, besides much sulphur, about 20 per cent. of ash. It is singular that the coal in the middle and northern portion of this deposit should be so extremely pure, and that of the south so extremely impure.

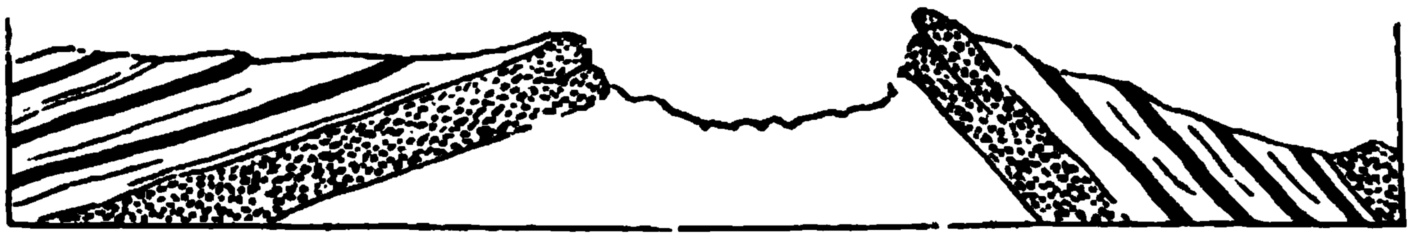
That portion of the field on the Black Warrior River, which is by far the larger body, may contain the third or fourth seam, in the lower series, but we could not recognize any above B, which undulates much, and comes in constantly recurring waves to the surface; though in the extreme southern edge of the field most of the coal is below water-level, and covered with the cretaceous formation of the Gulf shores. This part of the field is, therefore, low, and the coal-seams appear to dip towards and under the cretaceous strata until lost to sight and gone with a final plunge under the Gulf. (?) The strata rise rapidly towards the head of the streams until they reach the elevation of the Lookout range, and the plateaus of the Great Sand Mountain, overlooking the waters of the Tennessee.

Coal has been worked for a considerable period in Alabama at many localities, but chiefly on the Coosa, at Montevallo, on the Cahawba, on the Black Warrior, and on the Tennessee Rivers; but everywhere in the most primitive and costly manner.

We notice Professor Tuomey's remarks about the *cheapness of diving for coal* in the waters of Alabama, and we have no doubt any mode of mining coal would be cheaper than those generally practised. We have seen immense areas of a coal-seam uncovered to the depth of ten and twenty feet to obtain 30 inches of coal, and that generally below water-level. Ten tons of earth were removed for every ton of coal obtained, at many points along the Coosa, when a simple water-level might have obtained the same coal at one-tenth the labor.

Immense deposits of excellent iron ore exist almost entirely around the Alabama coal districts; but the best and most abundant appears to lie to the east of the coal. We have seen masses of the richest hematites, that may be called mountains without exaggeration, and beds of splendid fossi-

FIG. 126.



TRANSVERSE SECTION FROM THE COOSA TO THE WARRIOR COAL-FIELD.

liferous iron-stone that could be traced for a hundred miles, parallel with the Coosa. These ores were used extensively in the charcoal furnaces; but we have yet to hear of a single coke-furnace in Alabama, or of a pound of

iron having been made with mineral fuel in the blast-furnaces of that State.

The amount of coal mined in Alabama may be stated at 300,000 tons per annum.

Figure 126, from Taylor's Statistics, represents imperfectly the relative position of the coal-deposits of the Coosa and the Warrior. Both are represented at greater angles of dip than they naturally assume, and the number of seams on the Coosa is less than those represented. It is possible, however, that the seams are repeated by inversion on the east side of this field, as the strata in that direction are sharply folded, and the Great Valley limestone apparently overlaps the coal, much the same as it does at the New River coal-field in Virginia.

That portion of the field in Georgia is exceedingly limited, and similar to the coal of Tennessee. We shall not notice it separately, as Georgia receives all her coal from Tennessee, except such anthracite as may be received at her ports.

THE ALLEGHANY COAL-FIELD IN OHIO.

The coal-area of Ohio has been variously stated at from 5000 to 12,000 square miles. We have taken it at 7100 square miles productive coal-area, which will be its maximum, though the coal measures, including the Carboniferous limestone, extend over one-third of the State. But Ohio is, perhaps, as much diversified and cut by streams as West Virginia, though they are less in volume and length. Those within the coal-field generally rise towards or even beyond the outcrop of the coal, and flow towards the Ohio, down the dip of the measures.

All the streams feeding the Ohio, except the Great Kanawha and the Tennessee, rise within the margins of the Alleghany and the Central coal-fields. Most of them, however, rise within the Alleghany. The Ohio River flows nearly through the synclinal axis of the Alleghany basin from the great bend below, and yet north of Pittsburg, to the mouth of the Guyandotte; while the upper waters of the Ohio—the Alleghany, Monongahela, &c.—rise within the vast area that fills Western and Northwestern Pennsylvania, and descend towards the centre of the basin from the high plateaus of the Alleghany Mountains, the eastern escarpment of which forms the Atlantic margin of the great basin as it now exists.

The western margin of the Alleghany field is much lower than the eastern, and consequently the length of the eastern-dipping strata is correspondingly less than the western dip. The coal east of the Ohio has a general and gradual dip towards the Ohio; but the coal on the west of this river has a corresponding but reversed dip towards it as a common

centre: the streams follow, as a general rule, the inclinations of the strata over which they flow.

The highest portion of Ohio is lower than the outcrops, or eastern margin of the Alleghany field on the plateaus of that range; while the valley of the Ohio is much lower, of course, than the elevations of that State. Yet a large portion of Ohio, having its horizon on a common level with the most productive portions of the Alleghany and Central coal-fields, is destitute of coal or coal-bearing rocks. We can only account for such a deficiency by the theory of depression, or that of denudation. The last will not stand a critical examination, since it is not possible that an entire formation could have been swept away by water without leaving some relics of its former existence. But we have seen that a gradual depression of the interior of this great basin must have taken place during or after the formation of coal: we must, therefore, presume the area in Ohio, which is now destitute of coal, to have been above water during its formation.

It is evident that the interior of the great basin lying within the Alleghany and Rocky Mountains must have been at one time a vast lake or inland sea, having no connection with the great waters of the globe as they now exist. All the rivers of the Great Mississippi Valley take their rise within this basin as it now exists; though the Tennessee and the Kanawha, on the east, extend beyond the rim of the Alleghanies, which form the natural boundary of the present basin to the east.

This exception, however, is accounted for by the fact that the ancient granite boundary of this vast inland water was not so much depressed in the quarter where the Kanawha and Tennessee Rivers take their rise, as this granite rim was depressed both farther north and south.

The final depression of not only the granite rim or boundary of the ancient sea, but the entire Palæozoic structure formed in that sea to the south, effected its drainage into the Atlantic Ocean; but the depression of the interior or central portion was beneath the level of the Atlantic, forming the waters of the Gulf. Before this drainage was effected, certain portions of the great basin must have been above water-level; and that portion of Ohio which does not contain the coal measures must have been one of these dry spots or islands. That portion drained into the Lakes is outside the borders of the coal-field, and geologically below the level of our coal formations, and beyond the influence of those conditions, formerly described, which must exist in order to produce coal.

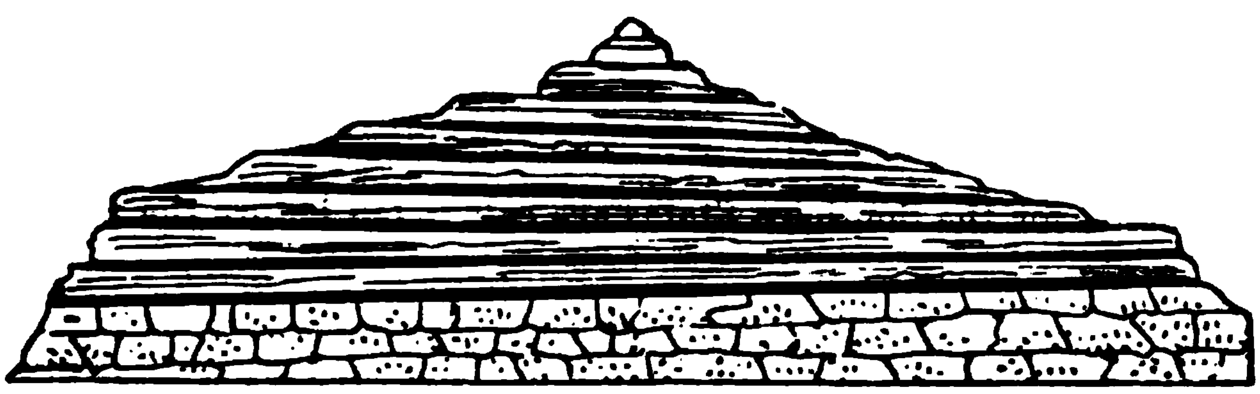
In the case of the denuded portions of Indiana and Illinois, along the Wabash, we have evidence of the former existence of coal; but over the space which adjoins the non-carboniferous portions of Ohio the former arguments hold good. The great coal-fields, however, which lie to the west of the Alleghany field, formerly existed, in all probability, in an unbroken body. That portion of the Great Central field which lies in

Indiana and Kentucky is only divided from Illinois by the valleys of the Wabash and Ohio Rivers, and we cannot doubt its former existence as a whole. We have, therefore, given it as a great coal-field, under the name of the "Central;" and this title may apply with equal propriety to the coal-field in Missouri and Iowa, which is only divided from the Central by the Mississippi, and the denuded area which has been swept away by its vast waters. We believe these great coal-fields once formed one unbroken coal-area, and may therefore be appropriately named, as a whole, the "Great Central coal-field," though we have named them respectively the "Central" and the "Western." But the time may come when the developments of the West will render the term "Western," as applied to the coal of Missouri and Iowa, a misnomer.

COAL MEASURES.

The coal measures of Ohio, lying immediately west of the Ohio River, contain the same coal-seams which the corresponding measures contain on the opposite side in Pennsylvania, West Virginia, and Kentucky. Opposite Pittsburg and Wheeling, the upper coals are found in Ohio, and of course all the lower coals. But to the north, and, in fact, all points towards the margins of the coal-field, the seams decrease in number, as they do in all coal-fields. The underlying seams always cover the greatest area, while the upper seams are the most contracted, on a natural principle developed in all basin-formations. When the basin is deep and narrow, the dip of the measures or strata is great, and the respective areas occupied by the upper or lower measures do not differ greatly. But when the basins are shallow, or the dips of the measures very gentle and the basins very wide,—as in the present case,—the edges or outcrops of the lower seams are always of far greater extent than the upper seams, as may be seen exemplified in any conical hill where the strata are nearly horizontal. All this, of course, is plain enough to the practical; but we write for many who know little about horizontal formations, or stratification generally.

Fig. 127.



HORIZONTAL COAL MEASURES.

We may thus explain why there are five or six productive coal-seams, averaging from 20 to 30 feet of coal, in the eastern part of the Ohio deposits, and only one coal-seam in its western and northern portions, pro-

ductive of only three to five feet of workable coal. By far the largest amount of coal in Ohio is deposited in the seam B, which ranges from 4 to 10 feet in thickness and is productive of excellent coal generally. This seam supplies most of the furnace-coal of Ohio, as it does in Pennsylvania. Towards the northern portions of the field it is used raw in the furnace, and found to answer a good purpose; but to the south it contains too much bitumen for this purpose, and requires to be coked.

Up to 1850, most of the Ohio blast-furnaces used charcoal; but perhaps the larger quantity of pig-iron is now produced with coke or raw coal. The same may be said of the locomotives which work the numerous railroads that traverse Ohio: they now use coal instead of wood.

There were 50 furnaces in blast in Ohio during 1864, and of these 20 may be stated as using coke or raw coal; and, as coke or coal furnaces are always larger than charcoal furnaces, those using mineral fuel must have produced more iron than those using charcoal. Large quantities of coal are mined and shipped down the Ohio, or sent by rail to Lake Erie, and from thence to the various ports on the Lakes.

The amount of coal raised in Ohio is stated to be one million tons per annum: we think this, however, is much below the mark, and may be about the amount shipped, or used in the furnaces, mills, cities, and locomotives, but evidently does not include the coal used for domestic purposes in the interior towns and villages. Ohio is a populous State, and wood is becoming scarce, and not available for fuel near her fast-growing towns and villages.

TABLE OF COAL PRODUCED FROM THE ALLEGHANY COAL-FIELD IN 1864.*

Pennsylvania	5,870,712
Ohio	1,000,000
Maryland	657,996
West Virginia	500,000
Kentucky	250,000
Tennessee	500,000
Alabama	300,000
	9,078,708

* The amounts for the Southern States are calculated before the war in 1861.

CHAPTER XIX.

THE NORTHERN AND CENTRAL COAL-FIELDS.

The Michigan, or Northern, Coal-Field—Extent and Character—Great Central Coal-Field in Illinois, Indiana, and Kentucky—Extent—In Illinois—Geology—Palæozoic Column—Pennsylvania and New York Equivalents—Elevation of the Coal Measures—Table—Coal-Seams—Mines—Production—In Indiana—Extent—In Kentucky—Extent—Depth of Measures—Vertical Section—Identification of the Coal-Beds—Production—Great Western Coal-Field—Area—Total Area of the Great Central Coal-Field—Geology of Missouri—In Iowa—Extent and Character—Arkansas—Kansas and Nebraska—Total Production of Bituminous and Anthracite Coal in the United States—The Resources of the Great Basin.

THE MICHIGAN, OR NORTHERN, COAL-FIELD.

THIS coal-field is located in the centre of the State of Michigan, and between Lake Huron and Lake Michigan. Its form and position may be seen on the miniature map of the Alleghany coal-field on page 318. The location of this field is extremely favorable, but its coal-seams are few and thin, and far from productive, as compared with the seams of Ohio or Pennsylvania. They are only two in number, and range from 3 to 5 feet in thickness, but the coal is pure and good. It is generally more bituminous in character than the coals of Ohio, and blazes with a bright, strong flame. It is not possible to determine whether the seams developed in Michigan are identical with those of the Alleghany field, from the general depreciation or thinning of the measures in the former field; but it belongs to the great Carboniferous formation of the Appalachian basin, and must, of course, contain the lower seams, if any. The general features and geology of the country differ only in the topography, which is not so much broken by erosions; but the measures are much thinner here than in the eastern basins. Yet, while the total thickness of the measures is comparatively limited, the coal, nevertheless, lies mostly below water-level, from the topographical evenness of the surface, the horizontal position of the seams, and the fact that the streams have not cut so deep into the measures as in other fields.

The extent of this field is stated at about 12,000 square miles, but the probability is that 6000 would cover the productive area.

But little has been done in the way of practical development in this coal-field, and we presume that 100,000 tons of coal per annum will cover the production.

THE GREAT CENTRAL COAL-FIELD.

The area of this coal-field is estimated at 50,000 square miles, of which 40,000 has generally been assigned to Illinois, 7700 to Indiana, and 3300 to Western Kentucky. But a more correct division will give 35,000 to Illinois, 10,000 to Indiana, and 5000 to Western Kentucky. The field is about 200 miles wide by 350 miles in length at its maximum dimensions, or rather over 150 by 300 as a mean. The coal deposits in Indiana are divided from those in Illinois by the Wabash River, which also forms the dividing line between these States through the coal-field. The Kentucky portion is divided from that in Indiana by the Ohio River.

The Mississippi divides this great coal-field from its counterpart in Iowa and Missouri, as shown in figure 117, representing the great basin. That they originally formed one great and continuous coal-field there appears to be no doubt; and a more comprehensive illustration would have properly included both the Central and the Western coal-fields in one map; but the form of these fields would not admit of their representation on a single page, to which we have confined ourselves in this work. We hope, however, to give a clear and comprehensive conception of the form, extent, and connections of these great coal-fields by the aid of the respective maps and figure 117, which defines their general connection.

Fig. 128.

PALÆOZOIC COLUMN IN THE CENTRAL COAL-FIELD, ILLINOIS.

CENTRAL COAL-FIELD IN ILLINOIS.

To illustrate the geology of the great basin known as the Mississippi basin, but which we have elsewhere called the Appalachian basin, we give, in connection with this coal-field, a geological section, or column, of the Palæozoic formations in Illinois. Figure 117 represents the gradual depreciation or thinning of the strata westward; figure 2, in Chapter II. of this work, gives its total thickness in the east, and figure 128 its thickness in Illinois.

The height of the Palæozoic column in Eastern Pennsylvania exceeds

five miles, and may be stated at 30,000 feet,—though it is in some localities over seven miles perpendicular; but 30,000 feet may be taken as the average in the vicinity of the coal-measures.

The Illinois section, which we copy from Professor Wilber's official map of that State, shows the total thickness of the same formations to be only 3310 feet from the Potsdam sandstone to and inclusive of the drift and Tertiary, which do not exist in Pennsylvania. A contrast of the two columns will convey a good impression of the general geology.

PALÆOZOIC COLUMN IN ILLINOIS.

Accompanying this section, figure 128, we give the Pennsylvania and New York equivalents, with the respective thickness of each. It will be noticed that few of the slates and shales of New York and Pennsylvania are found in Illinois, but that the limestones are continuous; and while the Chester or Carboniferous limestone is not represented in the anthracite regions of Pennsylvania, the Galena limestone of Illinois has its counterpart in the Auroral limestone, or No. II. The Galena limestone is only 300 feet thick, while the Auroral is often 5000 feet thick in Pennsylvania.

The Umbral red shale, or No. XI., entirely disappears, and the Vespertine, No. X., unites with the conglomerate, or millstone grit, forming, when united, 300 feet in Illinois, where the conglomerate proper is a thin plate of from 10 to 20 feet in thickness. Following the millstone grit, in Illinois and all the bituminous coal-fields of the West, is the Carboniferous limestone, which has a general thickness of 1000 feet.

Eng.	Pennsylvania State Survey.	Feet in Thickness.	No.	New York Survey.	Remarks.
Carboniferous.	Seral or Carboniferous......	3,500	XIII. XII.	Absent in New York.	The coal measures in Pennsylvania are about 2500 feet in thickness, exclusive of the conglomerate, which ranges from 20 to 1500 feet. The Carboniferous rocks of England comprise the Seral, Umbral, and Vespertine of Pennsylvania, thus:— Upper coal measures. Lower " " Millstone grit. Upper Subcarboniferous. Lower " "
	Umbral	2,000	XI.		
	Vespertine..........	2,000	X.	....	
Devonian.	Ponent	5,000	IX.	Catskill.	
	Vergent...............	9,000	VIII.	Chemung. Portage. Genesee.	
	Cadent................			Hamilton. Marcellus.	
	Post Meridian.....	....	VII.	Upper Helderberg. Schoharie.	
	Meridian............	1,500	VI.	Oriskany.	
Silurian.	Per. Meridian......	....		Lower Helderberg.	The total maximum thickness of the Palæozoic column in Pennsylvania is taken in the anthracite coal-regions. The general thickness is less than 38,000 feet, even in the east, and perhaps not over 20,000 feet in the eastern escarpment of the Alleghanies; and in North-western Pennsylvania it is not over 10,000 feet.
	Scalent	3,000	V.	Saliferous. Niagara.	
	Surgent...............			Clinton.	
	Levant	2,000	IV.	Medina. Oneida.	
	Matinal	1,000	III.	Hudson. Utica. Trenton.	
	Auroral...............	5,000	II.	Chazy. Calciferous.	
	Primal................	4,000	I.	Potsdam Sandstone.	
	Azoic	....	.	Gneissic.	
		38,000			

The Old Red Sandstone of the English, Catskill of New York, or No. IX. of Pennsylvania, may be represented by the sandstone following the Chester limestone in Illinois, which is 100 feet thick against 5000 feet in Pennsylvania. The St. Louis, Keokuk, and Burlington limestones, or Mountain limestones, are included in the Chemung and Portage groups; and the Oil, Black Slates, and Hamilton find their counterpart in the Cadent and Post-Meridian of Pennsylvania, or the Hamilton, Marcellus, &c. of New York. The Oriskany sandstone cannot be mistaken in either column; while the Niagara lime and the Hudson River group are distinctly named in each. The Galena lime is the equivalent of the Auroral in Pennsylvania, and the Chazy or Calciferous in New York; while the Potsdam sandstone is conspicuous as the base of the Palæozoic column in Pennsylvania and New York. In the West it is claimed that a lower fossiliferous sandstone exists on the Gneissic or Azoic; but there seems to be no great distinction between it and the Potsdam, or Primal, and both may be referred to the same formation.

The limestones predominate in the West, and the sandstones in the East; but some of the great sandstones have their horizon coextensive with the area of the ancient sea, yet invariably much thinner in the West than the East. They depreciate from massive formations several thousand feet in thickness to mere knife-edges, and from heavy, coarse-grained sandstones or conglomerates to fine-grained flaggy or slaty sandstones. This depreciation, particularly in the coal measures, is manifested in the same or greater proportions, considering the distance, in the Northwest as in the West. The coal measures in Michigan, containing the Lower coal series, which in Pennsylvania are from 500 to 700 feet thick, are only from 30 to 40 feet in thickness; which corresponds nearly with the measures on the western edge of Missouri.

The whole evidence goes to establish the propositions set forth in Chapters II. and III., describing the North American Continent as it formerly existed, or that portion of it which lies between the Rocky and Alleghany Mountains. We can conceive how these formations (the Palæozoic) arose, and why they were thicker at the East than in the West, why limestone in the interior of the great basin, and sandstone at its eastern edges, only on the basis of the theory set forth. A great inland sea stretching from the high, granite mountains in the East to those in the West; fierce and almost continuous volcanic action during the Gneissic period, while the metamorphic or crystalline sedimentary strata were deposited; violent but intermittent volcanic action during the Palæozoic ages, or while the fossiliferous strata arose in the waters of the ancient sea; a constant depression of the Eastern mountain-ranges, whence most of the material forming those vast lithographical structures came, and where all the volcanic vents existed to the East during the Palæozoic period.

The consequence of this natural process is that which we are now discussing. The deep basins of the East, formed by the depression resulting from long-continued volcanic eruption, received the largest amount of the vented volcanic material, and naturally the coarser matter settled in the nearest and deepest basins, while the finer and more limited amount floated away, on wind and tide and waves, to the centre and western parts of the ancient sea.

Limestones only formed in the East during periods of quiet; but they formed rapidly, since the carbonic acid and salts of magnesium and calcium existed in greater quantities where the heat was greatest; but they formed more constantly in the West, where comparative quiet almost constantly existed.

As the Eastern strata were depressed and the bounding mountain-ranges in that direction became lower in consequence, so the sea receded from the Western mountains and gradually exposed its western margins to the day, or left their extensive and shallow reaches in bog and swamp to form those vast prairies in the manner, perhaps, so ingeniously and scientifically described by Prof. Lesquereux, of Columbus.

We have adverted to this subject in this connection because, with the proof so abundantly furnished as we proceed, the subject becomes more clear to the mind, and the facts as they arise can be better appreciated and applied.

ELEVATION AND DEPRESSION OF THE COAL MEASURES.

The common level of the Illinois coal measures is above the Mississippi at St. Louis, which is 381 feet above sea-level, and the total thickness of the coal-strata is 900 feet; add to this the thickness of the Tertiary and drift, which is 350 feet, and we find the elevation of the highest points in Illinois within the coal-field to be 1631 feet above the Atlantic or the Gulf of Mexico, or the elevation of the coal measures to be 1281 feet above tide. The highest point on the Illinois Central Railroad is 1095 feet above the sea-level.

The Illinois or the Great Central coal-field in Kentucky and Illinois is the lowest point of the Mississippi Valley where coal is found; the deepest basins, however, exist in the Alleghany coal-field,—perhaps on the Big Sandy, in Kentucky. The following table represents the levels at which coal exists in the great Appalachian basin. By comparing this table with figure 117, it will be seen that the theory of *elevation* must be erroneous and singularly unequal; while that of depression, and contraction from volcanic action and condensation, answers every coincident and fits every circumstance, without the aid of miracles or natural phenomena, earthquakes, &c., which are unnatural and not natural processes, as described.

TABLE OF ELEVATIONS.

10,000	Common elevation of the Rocky Mountains.		
9,000			
8,000			
7,000	Probable height of the Rocky Mountain coal.		
		*Highest granite on the Atlantic border, south.	6,500
6,000	Highest coal of the Black Hills.	Highest granite on the Atlantic border, north.	6,000
5,000	Highest level of the prairies.	Highest granite formation in Virginia.	5,000
4,000	Highest Palæozoic formation in North Carolina.		4,000
3,000		Summit of Alleghanies..............	3,000
	Highest bituminous in Alleghany coal-field, 2,300 ft.		
2,000		Highest anthracite on Lehigh plateau.	2,000
	Highest level of prairies in Iowa, 1,500 ft. Highest coal in Illinois, 1,250 ft.		
1,000		Lehigh deep basins.....................	1,000
	Oil City, 1,110 ft.; Pittsburg, 680 ft.; St. Louis, 381 ft.; Lake Michigan, 587; Lake Superior, 627 ft.; Lake Ontario, 250 ft.; Lake Erie, 555 ft.; Lake Huron, 574 ft.	Pottsville, 620 feet......................	
Sea-level.			Sea-level.
	Deepest bituminous coal in Alleghany field, 100 ft.		
1,000	Lower or light oils on the Great Kanawha.	Lowest coal, Richmond (Virginia) coal-field, bituminous.	1,000
2,000	Atlantic bottom on the line of telegraph, 2,070 feet. (?)	Common depth of the anthracite basins in the Southern coal-field.	2,000
3,000	Deepest point of Palæozoic formation in Illinois, 3,000 ft.	†Lowest anthracite basins..............	3,000
4,000		Lowest coal formation in Deep River coal-field, North Carolina.	4,000
5,000	Deepest point on Atlantic bottom, 15,000 ft.		5,000

The coal measures of Illinois are stated by Prof. Wilber at 900 feet, which we presume to be nearly the maximum thickness, since it is not probable that the Pittsburg seam has any existence in Illinois, except in the highest portions of the southern part of the State. The deepest vertical section given in the Kentucky survey is about 1500 feet, embracing all the seams found in the Alleghany coal-field. If the Pittsburg seam exists at all in Illinois, it must be on the highest points and to a very limited extent. Generally the workable seams lie below the Mahoning sandstone, and may safely be identified with B, E, and one of the cannel seams, which we cannot place. In the northern portion of the State only one workable seam is found, which is identical with B, or the seam worked by the Buck Mountain Coal Company on the Lehigh.

The principal mines of Illinois are located at Lasalle, St. Johns, Duquoin, Belleville, Danville, Rock Island, Carbon Cliff, Sheffield, Kewanee, Col-

* The highest points along the Atlantic border are the Black Mountains, in North Carolina, 6500 feet; Mount Washington, New Hampshire, 6250 feet; Mount Tahawus, or Marcy, New York, 5300; Peaks of Otter, in Blue Ridge, Virginia, 5000 feet.

† The lowest anthracite basin is supposed to be 3000 feet below the sea-level. The Palæozoic formation still extends 35,000 feet below this point, and in all probability the gneissic formation is of equal thickness. These combined strata, now filling the bed of the ancient sea, are over 70,000 feet, or 16 miles, deep; whereas the deepest point in Illinois is less than one mile. We must, therefore, assign much of the difference to depression.

chester, Fairbury, Braceville, Morris, Caseyville, and Alton. The total amount mined and consumed per annum is stated by Wilber to be 650,000 tons. We presume the consumption, however, to be fully 1,000,000 tons, including the local consumption, which is not estimated above.

COAL-MINES AT ROCK ISLAND.

"The coal of Rock Island and vicinity forms a part of the northern border of the great Illinois coal-field. The lower Carboniferous rocks here come to the surface, resting upon Devonian or Silurian strata. Deeply cut by the great valleys of the Mississippi and its tributaries, and removed by extensive denudation, the coal formation exists as a series of outliers, occupying the highest points of land. In all the deep valleys it has been swept away, and its ruins have gone southward to form the rich alluvials of the Lower Mississippi and the deltas at its mouth.

"The coal is found associated with sandstones and limestones in thin bands between heavy beds of shale. One workable seam only has been found, which has an average thickness of about three feet six inches. It is, however, quite irregular, being liable to very sudden contractions and expansions. The coal lies high above the streams, and is very favorably located for mining. It is generally reached by drifting into the hill-sides. The roof is limestone or calcareous sandstone, occasionally separated from the coal by a thin band of shale. Beneath lies a very bituminous shale, sometimes graduating into an inferior coal, and resting upon a bed of fire-clay. This shale abounds in fossil plants, often in a very fine state of preservation, prominent among which are huge reeds and ferns, mingled with plants of great delicacy and beauty. The fire-clay has been tested and found valuable. It is extensively used by Thomas & Joury, at Carbon Hill, in the manufacture of pottery, fire-brick, and tile.

"Most of the mines of this district are small, averaging from ten to thirty tons daily yield. The mining is done at the outcrop on the hill-sides, and the coal is generally carted to Rock Island by teams. The mines are from eight to ten miles distant from the river; and this long transportation is a very serious drawback upon the profits. The only large mines are those of Cool Valley, owned by S. L. Cable, Esq., of Rock Island. This is one of the best-organized mines in the country. Mr. Cable has built a railroad, twelve miles long, from Rock Island to his mines, over which his coal is carried to market. His annual product is about 60,000 tons, which is marketed mainly at the river and carried westward into Iowa. It is extensively used by steamers, and supplies the large towns of Eastern Iowa with fuel and gas. About 80 hands are employed, most of whom are common laborers who have taken up mining and acquired their skill by practice in these mines. They work under an arrangement as

novel as it is successful. The miners and the owners of the mines are parties to a mutual understanding, by which the railroad receives one-third, the mine-owner another, and the operatives one-third of the price per ton which the coal brings at Rock Island. This arrangement works admirably. It secures the best class of labor, avoids strikes, encourages men to establish permanent homes, and secures the steady development of the mines. It is eminently profitable to all parties. It is intrinsically just and humane, and has the additional advantage of putting more money into the pockets of mine-owners and operatives than the old method.

"The mine is opened in the side of a steep bluff south of Rock River. The coal is brought to the cars, which run to the mouth of the drift, by mules, over a wooden track. The seam is here about four feet thick, with excellent roof and floor, but is subject to some slips and interruptions. In running the main entry back into the bluff, at a distance of about 60 rods from the opening, the coal suddenly gave out, and was replaced by a mass of sand and gravel, mingled with large stones and drift-wood. This occurrence puzzled the miners considerably, and was supposed by some to be a fault or slip of the strata. On examination, however, of the surrounding country, the real nature of the interruption becomes obvious. The coal and its associate rocks come in again, and are seen in their proper place, though a large extent of the formation is gone. It has been cut out by denuding agencies, similar to those which are now at work in every valley where water flows. But the space has filled up with material washed in by powerful currents while the surface suffered a temporary submergence. The phenomena probably belong to the drift epoch, when extensive areas of the earth, which had been above water for ages, subsided below the ocean and became covered with the deposits of clay, gravel, and boulders which form the surface so generally in the North temperate zone. (?) Possibly it is altered drift, washed in by the Mississippi at its flood when its waters flowed hundreds of feet above their present level. Fresh water has certainly stood on the highest lands of this region; for on the hill-tops deposits of loamy clay are everywhere visible, containing fresh-water shells. All shallow beds of coal are liable to these interruptions. In regions which have been subjected to extensive inundation, cutting broad and deep valleys, and especially where the deposit of drift is thick, the greatest care is required in opening mines where a heavy outlay is to be made. A thorough survey by a competent geologist is an essential prerequisite to any large investment in improvements.

"The quality of this coal is good, though hardly equal to the best coals of the State, as seen at Duquoin, Lasalle, Danville, and Fairbury.

"It is very compact, in thick layers, with mineral charcoal between, with some thin seams of carbonate of lime, and sulphate of iron in small quantity.

Specific gravity	1,363
Loss in coking	43.0
Total weight of coke	57.0
Ashes	10.0

"Vast quantities of small coal lie around the mines, waste and useless, which might be converted into the finest coke.

"The area covered by workable coal in the region of Rock Island is quite limited; and every ton will be needed for the local consumption and the country west in Iowa. It will not be carried north or east, as the Lasalle mines will more naturally supply that demand.

"The coke from this coal is used by John Deer, Esq., in his extensive works at Moline. Mr. Deer makes cast-steel ploughs of such superior excellence that they are even shipped to Europe. They are noticed in a recent Russian paper as being the best ploughs yet introduced into that country. It is also used in a raw state by S. W. Thomas, Esq., at Carbon Hill, in his extensive pottery-works, with success. These mines are of great value, and will be the means of building up extensive manufactures of all kinds at Rock Island and Davenport. The possession of cheap fuel will more and more determine the points to which raw material will be transported, and where the great centres of manufacturing industry will be established. E. D."

The foregoing quotation is from one of the late Chicago papers, sent us by a friend. We give it not as a description of the most prominent mines, but to convey an idea of the manner and modes of mining.

The mines of St. Clair county, near St. Louis, are perhaps the most extensive in Illinois, and comprise nearly 50 operations, producing about 300,000 tons annually, besides the local consumption, which has been stated at 200,000 tons. The adjoining mines of Madison and Grundy counties produced in 1864 over 100,000 tons. The mines of Kewanee are said to produce 6000 tons per month during the winter season, and other mines along the line of the Chicago, Burlington & Quincy Railroad about as much. The annual production may be stated at 100,000 tons.

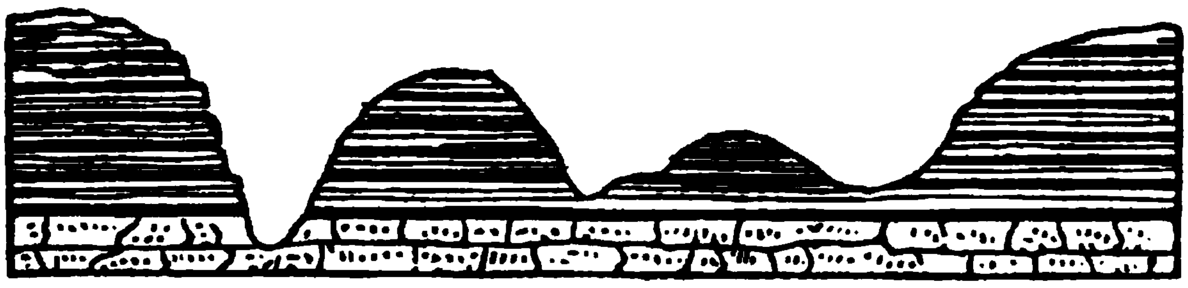
At Lasalle there are also some important mines. That of Col. Taylor is the most extensive in Illinois, and produces about 300 tons per day. It is mined from a single shaft, which is 250 feet deep. This mine is under the superintendence of an old Pennsylvanian, from the Broad Top and Cambria county coal-region. The value of the coal at the mines is fixed at twice the price paid for mining.

We thus find that the mines of St. Louis or vicinity produce 500,000 tons, those of Rock Island over 100,000, those of Kewanee and vicinity 100,000, and those of Lasalle over 100,000, per annum,—making a total of 800,000 tons. It is evident that over 200,000 tons are mined from the

mining-localities formerly named and not here repeated: consequently, the production of Illinois must be over 1,000,000 tons annually.

Figure 129 represents the erosion in a large portion of this coal-field.

FIG. 129.



EROSION OF THE COAL MEASURES.

The seams are horizontal, and the features of the erosion are similar to those of Cumberland, Maryland, or Kanawha, West Virginia, except that both these regions have an inclination more perceptible than the dip of the Illinois measures, which dip slightly from north to south at an imperceptible angle.

CENTRAL COAL-FIELD IN INDIANA.

That portion of the Central coal-field lying in Indiana we have stated at 6700 square miles of productive coal-area. The coal formation is perhaps fully 10,000 square miles in extent.

The maximum depth of the coal measures is greater than in Illinois, but less than in Kentucky. The number of workable seams is 6 in some localities with a total thickness of 35 feet; but generally only three seams are of workable size, and towards the edges of the field only one is found of workable dimensions. The upper cannel-coal seam of the Kanawha does not seem to exist; but the lower cannel is good and productive, and from 3 to 4 feet in thickness. The fracture is conchoidal and rather dull. It is heavier than ordinary cannel, weighing 75 pounds to the cubic foot, and contains

Fixed carbon	59.40
Volatile matter	34.90
Ashes	5.70
	100.00

Notwithstanding its conchoidal fracture when broken across, it parts readily in flakes, and burns without any tendency to coke or cake. Its ready ignition, rapid combustion, and bright fierce flame render it a splendid fuel for Western steamboat use, in generating steam rapidly; but it is less durable than the harder bituminous of bed B,* which contains

* We are not certain of the identity of the Cannelton cannel of Indiana with the Kanawha lower or the Breckinridge cannel. It seems to be the lower coal-bed, or A, which frequently changes to cannel westward, and identical with the Caseyville cannel, which contains 20 per cent. of ash.

less bitumen and more carbon than any of the other workable beds in Indiana. The amount of workable coal in this part of the Central coal-field may be stated at an average of 20 feet, distributed in from one to six seams. The amount of coal mined can only be approximated at present; but it cannot be less than 500,000 tons annually.

Figure 130 is from Taylor's Statistics. We introduce it merely to

FIG. 130.

a, coal measures; *b*, *b*, Carboniferous limestone; *c*, Waverly sandstone; *d*, Marcellus and oil shales.

convey an idea of the relative width in the lower end of the Central coal-field and the progressive depreciation westward.

CENTRAL COAL-FIELD IN WESTERN KENTUCKY.

A singular increase in the thickness of the coal measures takes place in the Western-Kentucky portion of the Central coal-field, which we can only account for by the greater angle of dip and, consequently, deeper basins of this region. A basin of coal is always filled to its own peculiar horizon, which, of course, must conform to the coal-field in which it exists. But in a field where three or four seams may be the general number found within the measures, a local depression having the basin-shape and lying below the base of the surrounding measures will accumulate an additional amount of measures, and, consequently, additional seams, until the general horizon of the field is reached. But, singularly, the lower seams are always identical with each other all through the field, while the local additions are always the upper ones. We said singularly; but naturally would be the best expression. It presents evidence that all coal-seams are formed in water, and that as soon as the formation reaches the surface the growth of coal and the accumulation of the measures cease.

In Kentucky the basins lie deeper than in any other part of the Central coal-field, and perhaps as deep as the deepest part of the Alleghany coal-field. As an evidence of depth, we find the coal-seams to be of a minimum thickness, while they are in maximum numbers. All our investigations prove that the coal-beds are invariably thin when formed in basins of great depth, or in very shallow basins. The thickest seams always exist in basins of a medium depth.

We consider basins of 2000 feet, and of course over that depth, to be deep basins, and those of 1000 feet depth to be medium basins. By

shallow basins we mean bogs, swamps, and shallow waters from 0 to 100 feet in depth.

The Alleghanies rise generally about 2500 feet above sea-level, though some points attain an altitude of 3000 feet or more. The highest coal on the eastern margin of the Alleghany field, outcropping on the high plateaus of the Alleghany Mountains, is about 2300 feet above tide. This we must accept as the water-line of the great basin at the commencement of the coal era. The elevation of the Ohio at Cairo is 290 feet above the sea-level: therefore, if the coal-basins of Western Kentucky are not deeper than the waters of the Ohio, the depth of the water in those basins must have been 2000 feet deep at the commencement of the coal era. We know that this does not conform with the theories of coal formation generally entertained, and that a great depression must have taken place in the Mississippi Valley; but we know, too, that this depression was greater in the East than in the West, and greater beneath the Alleghanies than beneath the basins of Western Kentucky. If the centre of the great basin was depressed during the formation of coal, the depression of the Alleghany range was greater: therefore the depth which we have cited will hold good under any argument. We do not, however, set up the foregoing depth of coal-basins as an arbitrary rule. We have simply come to this conclusion from the examination of a number of basins; but we are bound to state that the process of contraction has undoubtedly increased the depth of most of our coal-basins, though the relative proportions have been retained; and, under such circumstances, we might assume 1000 feet as a maximum, 500 feet as a medium, and 100 as a minimum depth to coal-basins as they originally existed at the commencement of the Carboniferous era. But the facts contradict this; and all the great coal-fields in Europe and America, having their original or normal forms unaltered, prove the greater depth to be the nearest correct.

The following vertical section is from Dr. D. D. Owen's survey of Western Kentucky, which we copy from a pamphlet on the identification of the coal-seams, kindly furnished us by Professor Lesquereux, of Columbus, Ohio.

We must here state that our identification of the Lower seams does not agree fully with that of this eminent Palæontologist, simply from the fact that he has accepted the Wilkesbarre section, as laid down in the geological survey of Pennsylvania, as correct, and has identified the Mammoth with B in consequence. But, notwithstanding this *grave error,*—which must have occasioned him much difficulty and uncertainty at times, for which, however, he is not responsible,—it is wonderful how nearly the identification, which we have worked out from the actual facts presented, and which he has scientifically arrived at by Palæontological evidence, agree with each other.

Until this moment we have been working without the least knowledge

of each other's labor; and though we may differ widely in points of mere opinion, the facts elicited, though obtained by different processes and from different points of investigation, are corroborative and in evidence of the correctness of the modes by which the result is obtained.

Vertical Section, Union County, Western Kentucky.

		Ft.
	Surface	50
	Coal	0½
	Measures	60
	Coal	0¾
	Measures	35
	Coal	0½
	Measures	102
J	Coal (Waynesburg)	2½
	Measures	115
I	Coal	1
	Measures	77
H	Coal	0½
	Measures	100
G	Coal (Pittsburg, or Primrose)	3
	Measures (slate and fire-clay)	10
	Coal (Pittsburg, or Primrose)	5
	Measures, including Pittsburg limestone	40
	Coal (cannel?)	3
	Measures	60
	Coal (cannel?)	5
	Measures	20
	Coal	0½
	Measures	70
F	Coal	2½
	Measures (Mahoning?)	110
E	Coal (cannel?)	3
	Measures	65
	Coal	4
	Measures	95
	Coal	3
	Curlew or Freeport limestone	25
	Coal	1
	Measures	130
D	Coal	2
	Measures	100
C	Coal (cannel?)	2
	Measures, including ferriferous limestone	55

		Ft.
B	Coal	5
	Measures	30
	Coal	0¼
	Measures, including conglomerates	110
A	Coal (cannel?)	1½
	Conglomerate	

We obtained the foregoing data too late for the purpose of illustrating them with an engraving, uniformly with the other principal sections in this work.

The celebrated Breckinridge cannel coal we presume to be in position over B, and identified with the lower cannel on the Great Kanawha, and is, therefore, the third seam from the millstone grit. The cannel-coal seams of Western Kentucky appear to be more numerous than elsewhere in the Western bituminous fields, except in the Great Kanawha Valley. In the Pennsylvania section, figure 118, though an equal depth of measures exists, there is less cannel, and not as many coal-seams.

We have been unable to locate the Kentucky cannel-beds correctly, for the want of the proper data. We will endeavor to do so in the Appendix.

The amount of coal mined in Western Kentucky may be stated at 250,000 tons per annum, and the whole production of the Great Central coal-field thus:—

Illinois	1,000,000
Indiana	500,000
Western Kentucky	250,000
	1,750,000

THE GREAT WESTERN COAL-FIELD IN MISSOURI AND IOWA.

The Great Western coal-field, as we before stated, is part of the Central coal-field, and might be appropriately described under the name of the "Great Central;" for such it is.

On the east of the Mississippi, the accompanying map displays the Central field in Illinois, divided only by the erosions of the vast river which separates these fields; and on the west of the Missouri River we might display a continuation of this field to a limited extent in Kansas and Nebraska, as illustrated in figure 117, or the transverse section of the great basin.

The area, as shown on the map, is 45,000 square miles, of which 21,000 square miles exist in Missouri and 24,000 square miles in Iowa.

The dimensions or productive extent of the Great Central coal-field inclusive—applying this title to the coal-fields in the central portion of the great basin—may be set forth thus:—

	Sq. Miles.
Illinois	35,000
Indiana	10,000
Western Kentucky	5,000
Iowa	24,000
Missouri	21,000
Nebraska	4,000
Kansas	12,000
Arkansas	12,000
Total	123,000

The denuded area over which this great field once extended, connecting all in one vast basin, must undoubtedly be double the extent of the present productive area as above set forth.

The western portion of the field contains only the lower seams, and seldom more than three; in most localities only one workable bed—the persistent and extensive B—is found.

Figure 131 will illustrate the geology of Missouri, which differs little from that of Iowa. In relation to the coal of Missouri, we make the following quotation from the geological survey of that State by Professor Swallow:—

"Workable beds of coal exist in nearly all places where the coal measures are developed, as some of the best beds are near the base and crop out on the borders of the coal-field. All the little outliers along the borders contain more or less coal, though the strata are not more than ten or fifteen feet thick. But, exclusive of these outliers and local deposits, we have an area of 26,887 square miles of the regular coal measures. In many places the thickness of the workable coal-beds is over 15 feet; and the least estimate that can be made for the whole area is 5 feet.

"This will give 134,435,000,000 tons of good, available coal in our State. (?) In our efforts to estimate the economical value of so vast a deposit of this most useful mineral, we must constantly bear in mind the position of these beds beneath the soil of one of the richest regions on the continent, within a State whose manufacturing and commercial facilities and resources are scarcely inferior to any, and adjacent to the Missouri River, and the Pacific, the North Missouri, and the Hannibal & St. Joseph Railroads. With all these advantages of location, the certainty that these coal-beds can furnish 100,000,000 tons per annum for the next 1300 years, (?) and then have enough left for a few succeeding generations, is a fact of no small importance to the State."

GEOLOGY OF MISSOURI.

Figure 131 illustrates the geology of Missouri, and the relative position of the coal-seams. The coal measures embrace a thickness of 650 feet, and

the number of seams, small and large, is 9; of which only three can be considered workable.

Fig. 181.

The geology of this State differs but little from that of Illinois, and perhaps were the surveys both made by the same individuals there would be no difference, except in local distances.

VERTICAL COLUMN.

The coal measures are not as thick by 150 feet in Missouri as they are in Illinois, and several of the sandrocks are wanting; but while the sandstones decrease, the limestones increase. The magnesian limestones, intercalated with calciferous sandstones, are 1000 feet thick in Missouri; but the Galena limestone, its equivalent, is only 300 feet thick in Illinois. (?)

In Pilot Knob, Iron Mountain, and vicinity, the gneiss makes its appearance, and the ores of that celebrated region exist in the gneissic formation, intersected, however, by porphyry, which seems to have been ejected with the metallic veins through the igneous or granitic rocks below. The identification of figure 131 with figure 128 will be found complete, though the names of the formations are frequently different. The general continuation of the limestones of Pennsylvania, and the absence of the sandstones, will be noticed.

IOWA.

The coal measures thin rapidly in a northern direction from Missouri, and in Iowa the productive measures are generally less than 100 feet in thickness, containing only one reliable or workable bed of coal, which ranges from 4 to 5 feet in thickness.

Professor Owen, in his report, says,—

"Coal and iron in abundance have been found, and other valuable minerals. The coal measures of Iowa are shallow; much more so than those of the Illinois coal-field. They seem attenuated as towards the margin of an ancient Carboniferous sea, not averaging more than fifty fathoms (300 feet) in thickness. Of these the productive coal

VERTICAL SECTION ILLUSTRATING THE GEOLOGY OF MISSOURI.

measures are less than one hundred feet thick. The thickest vein of coal detected in Iowa does not exceed from four to five feet; while in Missouri some reach the thickness of twenty-five feet(?) and upwards. In quality the coal is on the whole inferior to the seams of the Ohio Valley. To this, however, some very fair beds form exceptions.

"Of this coal-field in Iowa alone, not including its extension south into Missouri, the dimensions are as follows. Its average width from east to west is less than 200 miles; its greatest length from north to south is about 140 miles; its contents, about 25,000 square miles; its extent, measured in a direct line, is 200 miles in a northwesterly direction up the valley of the Des Moines."

The amount of coal produced in the Great Western coal-field in Missouri and Iowa is about 500,000 tons per annum.

The coal-fields of Arkansas, Kansas, and Nebraska are but partially developed, and little can be said concerning them of practical value, more than to state their extent and character.

The coals of Kansas and Nebraska are merely the thin western edges of the Great Central coal-field, where only the lowest beds exist, and where frequently only the lowest bed of thin coal is found. In Arkansas the coal measures approach nearly the character of those in Missouri, and stand in much the same relation to the centre of the great basin.

In summing up, we find the total area of productive coal measures within the great Appalachian basin to be 190,000 square miles, exclusive of Texas and the coal that may and does exist on its extreme western edges. This vast area may be properly divided into two distinct and comprehensive fields, under the respective names of the Great Alleghany or Eastern coal-field, and the Great Central coal-field. The time has not yet arrived to include the "Great Western coal-field,"—though we have thus denominated the western portion of the Central coal-field.

The division of the great coal-areas described, or the portions existing in the respective States within their limits, may be enumerated thus:—

GREAT ALLEGHANY COAL-FIELD in

	Sq. Miles.
1. Pennsylvania	12,656
2. Ohio	7,100
3. Maryland	550
4. West Virginia	15,900
5. East Virginia	150
6. Kentucky	10,700
7. Tennessee	3,700
8. Georgia	170
9. Alabama	4,300
	55,226

GREAT CENTRAL COAL-FIELD in

	Sq. Miles.		Sq. Miles.
1. Illinois	35,000	5. Iowa	24,000
2. Indiana	10,000	6. Arkansas	12,000
3. Western Kentucky	5,000	7. Kansas	12,000
4. Missouri	21,000	8. Nebraska	4,000
			123,000
		Alleghany coal-field	55,000
		Michigan, or Northern, coal-field	12,000
		Total	190,000

BITUMINOUS PRODUCTION.

The total present production may be stated approximately thus:—

	Tons.
Alleghany coal-field	9,078,708
Central coal-field	2,250,000
Michigan, or Northern, coal-field	100,000
Total for 1864*	11,428,708

TOTAL PRODUCTION.

The total production of the United States, including the anthracites and semi-bituminous of Eastern Pennsylvania, stands thus for 1864:—

	Tons.
Anthracite	10,000,000
Semi-bituminous	635,319
Southern bituminous (Virginia and North Carolina)†	200,000
Western bituminous	11,428,708
Total product	22,264,027

RESOURCES OF THE GREAT BASIN.

The resources of the great inland basin which we have been describing are, without exception, superior to any thing of the kind which the world can present,—in fact, so immeasurably superior that no comparison can be made even with the most favored mineral region yet known to science or the world.

* The production of the Southern States is estimated by the amount mined before the war. During the war, and since, but a limited proportion of the quantity assigned them has been produced. In a former page will be found the production of each coal-producing State; but, deducting the entire production of the Southern States, the amount of coal produced in 1864 will still be over 20,000,000 tons.

† This amount was not reduced during the war; but it may be less in 1865.

Of the 1,500,000 square miles within this immense basin, drained by the waters of the Mississippi, the Alabama, and the Rio Grande, there is scarcely a mile that is not available as agricultural or mineral land. Within the basin the greatest portion of the coal-fields presents a rich and productive soil, and the margins of the basin, terminating on the limestones or the gneissic mineral rocks, not only present the richest beds of iron, copper, and lead, but also a surface generally susceptible of cultivation and much of it extremely productive.

The form of this great basin is also eminently available to the industrial pursuits and economic uses of society. The rivers tend to one common centre, and their descent is so uniform and gradual that most of them can be navigated almost to their sources, while their banks present ready grades for our great railroad-lines.

The entire area thus drained is capable of supporting a population as dense as that of England, with more ease and equal wealth; or the great Mississippi basin is fully capable of supporting one-half the population of the earth in wealth and luxury. It may be many years, perhaps centuries, before 500,000,000 inhabitants shall crowd this vast and rich arena. But there is no limit that we can now place to the increase of our population; nor can we say that the time will not come when even the number we have specified shall find free homes in the magnificent plains beyond the Alleghanies.

Our coal-fields then will fulfil the uses designed by Providence, and our mountains of iron will be reduced to implements of industry and trade, and all may conduce to the prosperity and happiness of a nation having no rival or counterpart, where the people are only accountable for their own welfare and peace, and where the blessings of Heaven may be enjoyed "under our own vine and our own fig-tree, and none to make us afraid."

CHAPTER XX.

NORTHEASTERN COAL-FIELDS.

New England Anthracite Coal-Fields—Imperfect Formations—Gneissic Deposits—Altered Rocks—Character of the Coal and the Coal-Fields—Mining Operations—The Arcadian Coal-Fields in the British North American Provinces—Formation of Coal—Depression of the Basins—Growth of the Limestone—Coal and Coal Measures—Thickness of Coal-Beds—Area—Nova Scotia—New Brunswick—Prince Edward's Island—Cape Breton Island—Newfoundland—Oil-Coal—Gas-Coal—Comparison with the Gas-Coals of Virginia and Pennsylvania.

NEW ENGLAND ANTHRACITE FIELDS.

THE coals of the New England States are anthracite in character, and were formed under the same influences which produced the anthracite of Pennsylvania; but the geological conditions differ materially, and the intensity of the heat to which the bitumen and carbon forming the coal were subjected in consequence, destroyed their value as a fuel.

The coal-basins of Massachusetts are found in or closely upon the gneissic rocks, and partake, in consequence, of all the imperfections which always accompany such formations.

The depreciation of the Palæozoic rocks in the northeastern limits of the ancient Appalachian Sea are almost as marked and uniform as that which notes their progress west. But in the New England States existed the granite boundaries of the great basin, and the formations of a later period only took place in the depressions of the granitic or gneissic rocks.

The coal, therefore, is peculiar, or characteristic of all such formations, —thin and irregular in its stratified beds, or subject to sudden contractions and enlargements, to upthrows and downthrows, slip dykes and rock faults, saddles, troubles, hitches, dirt faults, and all the ills of coal-basins existing without those necessary conditions for the production of coal noticed in Chapters III. and IV. of this book.

It has been stated, and partially demonstrated, that this coal really does exist in the true Palæological position of our great coal-fields, and that the sedimentary strata in which it exists have been metamorphosed by heat into the sub-crystalline; but this does not alter the effect, since intense heat only could change the rocks in this manner, as all the metamorphic or gneissic rocks have been changed by the same means.

The basins in which this coal exists are extremely irregular, and must

have been always unfavorable for the even and uniform stratification of valuable coal-beds; but these unfavorable conditions have been subsequently increased in deformity by lateral contractions, which have doubled and folded the strata in sharp waves, and not only crushed the coal, but by the irregular movements of the crust caused the coal-beds—and of course the accompanying strata—to slide above or below their true horizons of connection.

We find the same cause operating violently on the value of the Piedmont and New River coal-fields of Virginia, as far as the slides and faults are concerned; but in these Southern fields the heat has not been so intense; only a small portion of their coals has been changed to anthracite; but the anthracite is always on the side nearest the regions of heat, and the bituminous coal is always most remote.

In the anthracite coal-fields of Pennsylvania an immense thickness of sedimentary or Palæozoic strata existed between the coal and the regions of heat, and formed an even and uniform floor for the reception of the coal measures. It is possible and probable that the intensity of heat and volcanic action was far greater in the vicinity of the Pennsylvania than the New England anthracites; but the interposition of the immense shield of Palæozoic strata not only preserved the coal from actual contact and destruction, but added materially to the growth of the coal-beds by the production of the carbon and bitumen which escaped from them.

Nothing can be more evident than the fact that the salvation of our magnificent anthracite fields is due to the immense thickness of the Palæozoic or stratified floor upon which they rest. Had it not been for this protection, we should have had distorted and jumbled basins of plumbago, coal, dirt, slate, and rock. Even under the favorable circumstances in which they exist, some of our deepest and largest basins nearest the regions of volcanic heat have barely escaped its destructive influences.

In Pennsylvania, as in all anthracite basins, the hardest and purest anthracite is always nearest the point from whence the heat emanates, and the softest or semi-bituminous is most remote, but with this exception: when the coal is unprotected from the intense heat by intervening strata, it is frequently destroyed by that heat, or subsequently crushed and distorted by the contractions of the crust when condensed by the evaporation or loss of the same, viz., heat.

Various attempts have been made to develop the coals of New England, by practical as well as those who were not practical men; but they have all resulted in failure, not for the want of means or experience (except in a few cases), but because the beds were too unreliable and irregular to permit the production of coal with economy, or in competition with mining operations in the reliable coal-beds of Pennsylvania.

We give below a section from Taylor's Statistics, across the Portsmouth

basin in Rhode Island, from Mount Hope Bay to Narraganset Bay, looking north.

The centre of the basin, or the measures overlying the coal, appear to consist of altered sedimentary rocks, metamorphosed from the common

FIG. 182.

TRANSVERSE SECTION, PORTSMOUTH ANTHRACITE BASIN.

slates and sandstones to the crystalline, sedimentary, or metamorphic, by heat in water. The coal rests on a coarse conglomerate, made up with the fragments of primitive rocks, but singularly impressed with fossil forms peculiar to later ages; thus presenting evidence of the existence of the older rocks in superior position, or at greater elevation than the basin in which this coal was found. There are three seams of coal outcropping on the western side, dipping towards the centre of the basin, at an angle of 45°, but flattening towards the centre. They are all much crushed and irregular. The average size of these seams is about 3 feet; but they are constantly liable to sudden changes, and vary from a few inches to as many feet in a short distance.

The outcrops frequently yield plumbago, and occasionally nests of almost pure graphite are found in the coal-beds. That near the surface is collected and sold as black lead, under the name of "British lustre," and makes a good polish for stoves, &c.

Notwithstanding the defects and irregularities of these coal formations, the coal when in its best condition is very good, and presents the following analysis:—

Carbon	87.40
Moisture	6.20
Ashes	6.40
	100.00

which indicates a true anthracite; and most of our geologists who have examined this region pronounce the coal of great local value. Professor Hitchcock says, "Ere long, the anthracite of Rhode Island, and even that of Worcester, will be considered by posterity, if not by the present generation, as a treasure of great value." And in publishing his final report in 1840, he says,—

"I became satisfied that a part of this region was a true coal formation, and so marked it on the map. I now go a step farther, and maintain that the whole of this tract, embracing not less than 500 square miles, is a genuine coal-field that has experienced more than ordinary metamorphic

action. The metamorphic action to which this deposit and the coal have been subject is twofold, viz.: first, mechanical; second, chemical.

"The mechanical forces seem to have operated on the strata containing the coal in a lateral direction, so as not only to raise them into a highly inclined position, but also to produce plaits or folds such as would be formed if several sheets of paper lying upon one another were taken into a man's hands and by pressure on the opposite edges were crumpled so as to form ridges and hollows.

"The chemical metamorphoses which these rocks have experienced consist mainly in such effects as heat would produce.

". . . . The evidence seems very strong on which I base the conclusion that the Bristol and Rhode Island deposits, with vegetable remains, possess much the age and character of a true coal-field as the Carboniferous period of the geologists.

"I. In the first place, the general outline of the surface over this field corresponds with a regular coal-field or basin.

"II. The rocks correspond essentially to those of the coal measures.

"III. The number, position, strike, dip, and general character of the beds of coal already discovered in the district under consideration render it probable that it is all one coal-field, or essentially one.

"IV. The character of the vegetable remains found in connection with these coal-beds make it almost certain that they belong to the coal measures of the Carboniferous period."

Dr. Jackson thinks that the coal of Mansfield, in Massachusetts, may be worked with much profit if pursued with skill and judgment.

But the difficulty in the way of profitable mining in these New England coal-fields will be evident to practical men. Most of the coal lies below water-level, and can only be reached with long, deep slopes or shafts; and, as the beds are thin, a great distance must be opened out to produce even a small amount of coal.

The cost of erecting machinery and establishing mines under such circumstances is great, and the operation of them expensive; while at best the coal can only be obtained at double the cost in ordinary mining operations in other thicker and more regular beds. But, in addition to all those serious drawbacks, when the mines are opened and the proprietors commencing to realize, a sudden stop is put to the production of coal by a downthrow, an upthrow, a fault, or a thinning of the seam, which may continue to an indefinite extent.

These difficulties, or, as the Richmond (Virginia) miners call them, "troubles," are always met with sooner or later, and almost invariably end in failure. Three feet of coal would pay well in the New England States if the seams were regular and pure; but under existing circumstances it is a question if any mode of mining would result profitably. The only rea-

sonable chances for success are in basins of moderate depth, where the surface indications of dip and uniform structure are favorable, and where the beds are not folded and distorted, but inclining at an angle of 35° or less, with uniform evenness of intervening strata.

Under such circumstances a company might be justified in fairly developing the resources of the anthracite fields of New England; and if operations are conducted with especial reference to the circumstances in which the coal exists, and one-half the area be productive of paying or workable seams, the result might be favorable, since the coal is worth $5 per ton at the mouth of the pit in that region, lying in the midst of the great Eastern markets.

To insure success, or to prove the availability of mining, exploring drifts or gangways should be pushed constantly forwards through coal or fault, in order to open enough of the mine to provide workable coal at all times, leaving the thin or unworkable portions as pillars, &c. By working the best portions of the coal and driving narrow gangways through the unproductive parts, there would be reasonable chances of success.

THE ARCADIAN COAL-FIELDS.

These coal-fields are located in the extreme northeastern limits of the ancient Appalachian Sea, and, by their singular and peculiar structure, offer conclusive evidence in favor of the propositions we have set forth and the theory which we regard as established by the facts developed in regard to the volcanic origin of the Palæozoic strata in the great basin.

It also proves conclusively the subsidence and consequent submergence of the eastern granite shores of the ancient sea. We find the coal-beds existing under the sea, and the deep basins or measures in which these beds exist 10,000 feet or more below the common bottom of the Atlantic Ocean.

In this remote corner of the great Appalachian basin there seems to have been originally a series of deep basins, as in the region of Pennsylvania anthracite. But instead of these deep basins becoming filled up with the coarse sedimentary material of eruptive volcanoes, which existed in the vicinity of the anthracite basins of Pennsylvania, and, consequently, filled them, the former or Arcadian basins were slowly and gradually filled with the fine floating particles of dust or sand which the waves or the winds carried to a great distance, or became filled with the limestones which always accumulated in the regions of deep and quiet waters.

Active volcanoes did not exist to any great extent in the vicinity of the Arcadian fields. Those which may have existed were local, and effected no material change in the features of this portion of the earth's surface. But while volcanic vents did not exist to fill with decomposed or water-crushed lava the deep Arcadian basins, the eruptions of the long line of vents to

the south not only produced part of the material to fill them, but produced the result which depressed them below the level of the Atlantic.

We have no doubt but that this depression was slow, and the process of accumulating the vast pile of measures which now fill these basins gradual and continuous. While the coal formed in the anthracite basins and quiet reigned over the face of the vast inland seas, the limestones grew in Arcadia as they grew in the West, but perhaps faster.

The probable depth of these basins is not far from 20,000 feet, and the thickness of the coal measures in the deepest not much short of 15,000 feet. It is not probable that they were originally of this great depth, but that they have increased their original depth by the gradual subsidence which took down all the Eastern mountains from Newfoundland to Cuba, and, consequently, the accompanying and nearest basins. But that they were originally deep there can be no doubt, since the first 2314 feet of measures contain no coal, and the next succeeding 3240 feet only nine small seams of coal, aggregating 10 inches in all, and corresponding to our false coal measures. Above this there are 2082 feet containing no coal. Thus we find that over 7000 feet of measures were precipitated into the deep waters of the Arcadian basins before workable coal-seams did or could commence to form. Even then the depth in which they formed must be great, since the seams are extremely thin and unproductive: only 7 out of 47 seams are of workable size, and these contain only 20 feet of workable coal; while the other 40 seams are only from ½ an inch to 14 inches in thickness respectively.

These 47 seams exist in 2819 feet of measures. Above these are 2134 feet of measures, containing 22 unproductive or thin seams, aggregating 5 feet of coal. The upper series, and perhaps the only truly productive portion of this immense thickness of measures, is 2267 feet thick, and contains 12 coal-seams, the thickest of which is 36 feet, the whole aggregating 72 feet of workable coal in 6 seams.

The following data, from a reliable and interesting report by Capt. Thos. Petherick, may be depended on as representing the workable coal in the Pictou district of Nova Scotia.

NUMBER OF COAL-SEAMS AND THEIR THICKNESS IN THE PICTOU DISTRICT, NOVA SCOTIA.

No. 1.	"Main coal"	148 feet*	36 feet.
No. 2.	"Deep coal"		22 "
No. 3.	"Third coal"	280 feet*	4 "
No. 4.	"Purvis coal"		4 "
No. 5.	"Flemming coal"		4 "
No. 6.	"McGregor coal"		6 "
No. 7.	"Oil coal"	240 feet*	4 "
No. 8.	2d. Oil coal, not examined		?

At a point where the Pictou main coal is set down as 38 feet thick, the coal-benches or strata, with intercalated slates and clays, are thus described:—

	Feet.	Inches.
Roof, soft crumbling slate	0	3
Coal, shaly	0	6½
Coal, laminated, with "mother of coal"	2	0
Coal, cubical	3	2
Shaly ironstone and fossils	0	4½
Coal, laminated and cubical, with slates	9	3
Shaly ironstone, with fossils	9	8
Coal intermixed with iron balls	1	2
Coal with thin slates	6	7
Ironstone and sulphur	3	0
Coal with thin bands of slate	10	3
Coarse coal with slate and sulphur	1	0
Coal with sulphur rolls	2	1
Coal, laminated and cubical	2	3
Fire-clay	0	10

AREA.

The area of the Arcadian coal-fields is very extensive, and has been variously estimated from 5000 to 10,000 square miles. The total area is perhaps not less than 9000 square miles of coal measures; but we have hesitated to accept 2500 square miles as productive, since the large or workable seams cover but a comparatively small limit, while the underlying and unproductive seams exist over a wide extent of territory. The large upper seams have not been found in any but the Pictou basins. In Cumberland, at the Joggins, the third series of coal-seams appears to produce all the workable coal, which exists in the following order:—

		Feet.	Inches.
1. Upper or Pictou measures, not existing.			
2. 2134 feet, containing 22 coal-beds	(coal)	5	5
3. 2539 " " 47 "	(coal)	47	9½
4. 2802 " " no coal-beds			
5. 3240 " " 9 "	(coal)	0	10
Beds............78	(coal)	54	0½

The thickest bed among these 78 seams is only 4 feet 6 inches in diameter, and contains only 3 feet 8 inches of coal; while only two or three of the remainder contain more than 2 feet of workable coal; and since these seams are measured where exposed on a high bluff against the Bay of Fundy, or the Chignecto Bay thereof, where much of the original outcrops must have been swept away by the waters, and thus exposing the

coal-beds in their maximum condition, we may expect these seams to depreciate as they descend under the deeper parts of this deep Cumberland basin. It is not likely, therefore, that these seams will ever be very productive; and, since the same lower measures exist exclusively in New Brunswick, and perhaps in Prince Edward's Island and Newfoundland, these coal districts can never be considered productive to any extent.

The coal districts of the "Joggins," in Cumberland, and a corresponding horizon throughout this county, may produce coal for local demand, but little for exportation. The same may be said of the coals of New Brunswick, Prince Edward's Island, Newfoundland, the eastern extremity of Nova Scotia, and the southwestern end of Cape Breton Island. The only productive districts are those of Pictou in Nova Scotia and Sidney in Cape Breton Island; and we think our estimate of 2500 square miles quite as extensive as the productive area.

The coal-seams of Sidney, in Cape Breton Island, are of moderate dimensions. They may be thus enumerated:—

	Feet.	Inches.
Top seam	3	8
Measures	280	0
Loyd's Cove seam	5	0
Measures	730	0
Main coal-seam	6	9
Measures	450	0
Indian Cove seam	4	8

The Arcadian coal-fields in the British Provinces are divided by geologists into a number of districts or basins; but each district (as the Pictou) may be divided into several basins, in which the coal-seams undulate without coming to the surface, or they outcrop and the basins are divided by the Mountain or Carboniferous limestone, or the metamorphic and Plutonic rocks. The basins, however, are wide and deep, and the dip of the strata is gradual and uniform,—seldom over 20° in inclination, and generally much below.

These basins were not formed, as most of our Eastern basins are, on the sandstones which fill or prepare them for the coal measures, but are formed on the early limestones which succeeded the Potsdam sandstone and the gneissic period; and the succeeding limestones which fill our Western basins also make up the greatest portion of the measures in these. But perhaps there are more shales, slates, clays, and sandstones here than in the West, as these basins are deeper than the Western basins, and perhaps subject to more drift and debris from the higher grounds which surrounded them and from the great river which flowed into them. They were deeper than our Western basins; and, since all appear to have been filled

nearly to the brim, of course the deepest basins retained or held the greatest amount of sediment.

The amount of sulphur and iron pyrites in the measures and seams of the Arcadian fields is of serious injury to the value of the coal. We may account for its existence as a creation from sublimation; and since sulphur and iron pyrites exist in greatest profusion in the vicinity of the gneissic formation, and, consequently, in all coal-fields, stratified on or in the gneiss, or in proximity to it, we may account not only for the sulphur, but the sulphate of lime, or gypsum, which exists so plentifully in the Arcadian coal-measures, on the same principle, from the absence of the intervening masses of sedimentary sandstones which accompany all our great coal formations, except the Western. Most of the coals of Arcadia are of the fat or highly bituminous order, and plainly indicate their remoteness from the regions of the great heat which operated on the Pennsylvania anthracites.

The asphaltum and "oil coals" of New Brunswick and Nova Scotia contain as much bitumen as the best cannel coals of our Western fields. Some of the lower coals in the Pictou district stand thus:—

No. 1.		No. 2.	
Carbon	65.70	Carbon	25.23
Volatile matter	22.50	Volatile matter	66.56
Ash	11.80	Ash	8.21
	100.00		100.00

No. 1 is known as a steam coal; No. 2, as the Stellar or "oil coal." From the latter, oil can be made with profit,—perhaps on an equality with the cannel coals of the Great Kanawha, as far as the yield of oil per ton is concerned; but the relative cost of mining is much greater.

The Kanawha cannel-seams are from 4 to 6 feet in thickness above water-level, and can be mined with the greatest economy; while the "oil coal" of Nova Scotia lies deep below water-level, is comparatively thin, and divided thus:—

Common bituminous	16 inches.
Oil coal, "Stellar"	13 "
Bituminous slate, or shale	19 "

The seam is therefore only 29 inches in thickness, and the oil-producing stratum or bench only 13 inches: it will thus appear that the comparison is unfavorable to the Nova Scotia oil coal.

The common bituminous coals, however, of Nova Scotia are rich in bitumen, will produce certain amounts of oil, and may be considered good gas coal; though much of the Arcadian coals crumbles on exposure to the

atmosphere, and are subject to spontaneous combustion in consequence, as some of our Brooklyn friends may know to their cost.

A specimen of the best gas coal produced the following analysis:—

Volatile matter	32.0
Fixed carbon	59.3
Ashes	8.7
	100.0

This result is nearly the same as may be obtained from the Richmond (Virginia) coals, which are as favorably located to the shipping at tide-water as the coals of Pictou, and which, perhaps, can be mined with equal economy.

A mean of several specimens of Virginian gas-coal gave—

Carbon	58.50
Volatile matter	37.50
Ash	5.00
	100.00

An average specimen of the Westmoreland (Pennsylvania) gas coal, on the line of the Pennsylvania Central Railroad, which is used extensively for gas-making purposes in Pennsylvania, made the following analysis:—

Carbon	59.50
Volatile matter	36.00
Ash	4.50
	100.00

The cost of putting either of those two coals in New York cannot vary much from the cost of the Nova Scotia coal; and as they are equally as good, if not better, there can be no good reason why we should import gas coal to this country when we have more of the article than all the rest of the world combined. All such importations are simply wasteful leaks in our economy, which need stopping.

We shall not attempt to identify the Arcadian coals.

CHAPTER XXI.

VIRGINIA AND NORTH CAROLINA COAL-FIELDS.

Character and Location of the Southern Coal-Fields—Comparisons of the Eastern and Western Fields—The Formation of Coal—The Richmond Coal-Field—Granite Formations—Extinct Volcanoes—Transverse Section—Vertical Sections—Irregularities—Difficulties of Mining—South Side—North Side—Coal-Beds—Iron Ore—Natural Coke—Whin Rock—Cinder—Mines and Production—The Piedmont Coal-Field—Gneissic Floor—Trap Dikes—Coal-Beds—Dan River Coal-Field—Location and Character—Deep River Coal-Field—Great Depth of the Measures—Coal-Beds—New River Coal-Field—Proto-Carboniferous—Extent and Character—Ores—Outlet to the West.

FOLLOWING the description of the Western and Eastern coal-fields, we propose now to notice briefly the Southern independent coal-fields, which exist in the primitive rocks, or on the Atlantic slopes, and are formations of a later date than the Alleghany or Western bituminous coals, which belong to the true or Carboniferous era. These are small, impure, irregular, and insignificant deposits, compared with the great fields of the West; but being located in populous districts, remote from the regions of the true bituminous coals, they become of great local value. The cost of mining is always greater in such irregular formations, as we shall describe; but the coal is frequently pure enough for all practical purposes, except the smelting of iron, and generally of a character suitable for steam and most domestic purposes.

There are five distinct coal-formations in Virginia and the Carolinas. Three of these appear to be creations of relatively different ages, but all of later periods than those of the true formations.

The Richmond coal-field, near Richmond, in Virginia, lies within the granite basins of the primitive formations, but is nevertheless the latest creation. The Piedmont coal-field lies farther inland, in the counties of Prince Edward and Cumberland, and is within the gneissic basins, or the crystalline, sedimentary deposits of the metamorphic era; but the coal is of an earlier period than that of Richmond. This field is, perhaps, part of or a parallel formation with the Dan River coal-field. The Deep River coal-field, in North Carolina, is undoubtedly of a cotemporary date with the Piedmont and Dan River coal-fields; but the composition of its lithological structure is materially different, owing to the character of the sources from which it was derived. The New River coal-field, in Montgomery county, Virginia, essentially differs from all other coal formations in this country, and is perhaps the oldest coal in existence, or the creation

of the proto-Carboniferous ages. The character of the strata in which it exists belongs to the Vespertine period of the Palæozoic formations, and the fossils found therein apparently belong to the earliest dates of the Carboniferous era. Therefore, we place the New River coal-field in an older position than the great coal-fields we have been describing; while the coal-fields of the East, though occupying positions on rocks of the older formations, are still more recent in their respective creations.

The great coal-fields of the West, or, more properly speaking, of the interior portions of our continent, are among the oldest creations of coal, and the productions of the Carboniferous, or GREAT COAL ERA, when nine-tenths of the coal-deposits of the world were formed. Yet those immense deposits of coal are stratified in a comparatively late geological age, since which no great lithological structure has been created on this continent. The Permian, overlying the coal, caps the Palæozoic column but rarely in this country, and to a very limited extent. Therefore the coal measures proper may be considered the last great creation of this continent, since we consider the Lignites and Tertiary coals of the western margin of the Appalachian or ancient sea the cotemporary formations of those great Eastern beds of true coal. But those imperfect coals were created under less favorable conditions than the true coals of the East. The sea was shallow on its western margins, as all the circumstances—and they are numerous—prove. The vegetation may have been profuse in those shallow waters; but vegetation alone was not sufficient to form the vast coal-beds in the East, and did not form them in the West. The *hydro-carbon* oils, which were the productions of heat and the chemical combinations of certain minerals, as described in Chapter IV., were deficient in the western margins of the great basin, or ancient sea; and, consequently, the coal is also deficient and imperfect.

It may seem strange to those not familiar with geology and the circumstances attending the creation of coal, that the coal-fields of Virginia and North Carolina, which exist in the oldest rocks, should be of still later date than the fields reposing on our latest creations; but this apparent irregularity can be clearly explained, we think, on the principles advanced in Chapter III.

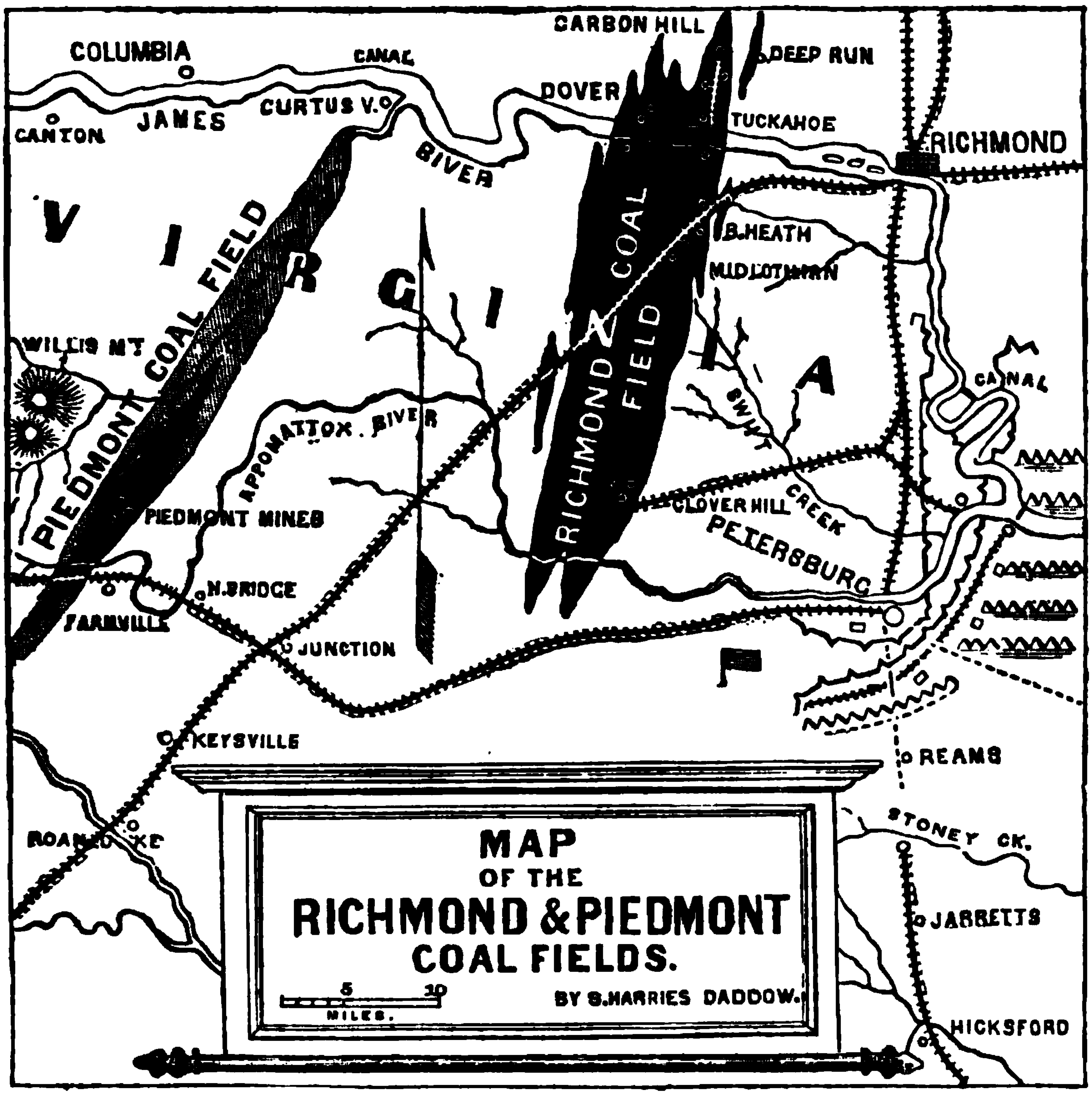
When the coal-fields of the interior—which we often speak of as the West, more from habit than from propriety—were in course of formation, the rocks in which the Southern coal-fields exist occupied an elevated position as a great coast-range of granite mountains, washed on the west by the waves of the ancient Appalachian Sea, and on the east, perhaps, by the Atlantic. But the position of those Eastern coal-beds was then high above water-level and destitute of all the conditions necessary to create coal. Since the formation of the Palæozoic strata and the coal measures they sustain in the ancient sea, the great coast-range subsided. Perhaps

the subsidence was gradual, and, as the sedimentary strata rose, the primitive crust was depressed, since the material which formed the one was at the expense of the other, as formerly stated in the early pages of this work.

The consequence of this change of physical structure is evident. When the granite mountains were diminished and sunk their tall heads beneath the waves of the Atlantic, and comparative quiet reigned along its volcanic shores, the small coal-fields of Virginia and North Carolina came into existence. They all occupy deep depressions or cavities in the primitive rocks,—perhaps the craters of extinct volcanoes,—and the materials composing their strata or measures are the debris of the higher lands, brought down by the rivers which traverse them, and in this respect are totally unlike the coal-fields of the Carboniferous era.

THE RICHMOND, OR TIDE-WATER, COAL-FIELD.

This coal-field crosses the James River about 12 miles west of Richmond, Virginia, and extends in a north-and south direction to the Appo-



mattox, 20 miles west of Petersburg. It is about 30 miles long by 5 miles wide, and contains an area of about 150 square miles. But perhaps less

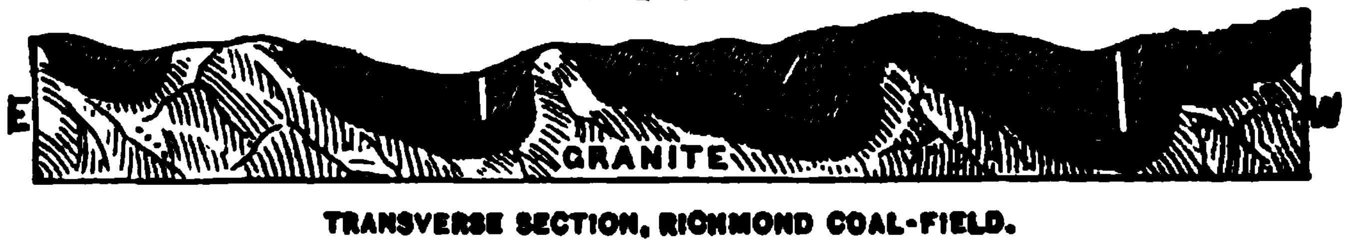
than half of this area contains available coal, owing to the undulations of the granite, which rises to the surface repeatedly in many sharp and abrupt peaks.

The basin is irregular, and is surrounded by a fine-grained granite, resembling sienite, which produces an excellent building-material, almost equal to marble in appearance. The interior of the basin presents peaks of granite of various textures, with occasional dikes of trap and porphyries. The field consists of a series of deep basins, the whole resembling the vast crater of some expired volcano, studded with sharp peaks and surrounded by rugged and irregular sides. The inequalities of the basin are in a measure modified by the sedimentary deposits which preceded the coal. But these deposits only filled the deeper hollows, leaving the coal in many cases to be stratified on a granite base. It seems evident that no subsequent crust-movements of importance have taken place in those Eastern and late formations. The deposits are thickest in the deeper basins or synclinals, limited on the inclining sides, and very thin on the anticlinals, thus proving positively that the basins existed much in their present condition when these deposits took place.

In the deep and inverted basins of the anthracite regions of Pennsylvania this is not the case; for the strata are frequently thicker on the inverted side than in the bottom of the deep basins or the more uniform dips, as may be observed at Pottsville, where the conglomerate is thicker—though leaning in an inverted manner from the perpendicular—than it is in the bottom of the basins.

We find some comparatively steep dips in the Richmond coal-field, considering them as original formations; but it is rare to find any available coal on these abrupt dips. The *coal*, as well as the sedimentary strata, is always thickest in the depressions, or synclinals, and thinnest on the saddles, or anticlinals. There are no *slips* and "*heaves*," as represented in Taylor's Statistics. All the irregularities are caused, with one or two rare exceptions,—to be subsequently described,—by the original inequalities of the granite floor, as approximately illustrated in figure 133.

FIG. 133.



TRANSVERSE SECTION, RICHMOND COAL-FIELD.

The inequalities are much greater locally than the generalised section portrays, and more distinctly represented by figure 107, under the chapter on Faults, &c. Those "troubles," as the cone-like synclinals are locally named, are numerous and really *troublesome*. The basins vary in depth; but the principal ones are about one thousand feet deep. The dips of the

measures on the east sides are from 20° to 40°, and sometimes much greater; but on the west the dips (dipping east) are from 25° to 80°, or sometimes perpendicular; and generally the descent to the basins on the east-dipping strata is in steps, the coal resting invariably on the less-inclining strata at the foot of each abrupt descent. The basins generally contain large deposits of coal, varying from 20 to 60 feet in thickness, particularly on the South Side, where all the available coal is found in one bed near the base of the measures, and not much above the granite.

Fig. 134.

VERTICAL SECTION, SOUTH SIDE RICHMOND COAL-FIELD.

Figure 134 represents the measures in the basins on the south side of the anticlinal, near James River. This anticlinal in a manner divides the northern end of the coal-field from the centre and south. It rises about two miles south of the river, and between it and the Black Heath and Midlothian mines, as marked on the map. The measures to the south of this anticlinal are as shown in this figure, and are materially different from those on the north side of the anticlinal, as will be noticed farther on.

There is only one bed of available coal on the South Side, at the base of the measures, and in basins from 700 to 1000 feet deep from the surface. The bed varies from 10 to 60 feet in thickness; but its average size is from 20 to 30. In those deep basins the coal is very dry and gaseous, containing a large amount of gas, but producing a limited quantity of bitumen. It cokes indifferently, being too dry to form a good solid coke, but is reasonably pure. It makes an acceptable gas, better than most of the Nova Scotia coals, and in larger quantities than the coals from the Eastern basins of the Alleghany field, but does not equal in quantity or purity the gas produced by the richer coals of the interior basins, or the cannels of Kanawha.

The modes of mining pursued are exceedingly primitive, and the cost of producing coal at least double that of our anthracite or Western coal-fields. Experience and capital would undoubtedly remove some of the expense, and render mining more profitable; but the formations of this coal-field are so peculiar and uncertain, that no man, however experienced in other coal-fields, should feel confident in this, without much study and investigation. With all the practical information that can be obtained, the chances will be unfavorable. It is true that most of the blunders and failures made in the Richmond coal-field are the results of ignorance,—but rather a want of local information than general mining experience. The changes are so frequent and irregular, and but seldom betrayed on the surface, which is a series of undulating sand-hills, that no judgment, however

practical, can be depended on without actual testing by proof-shafts. If a deep shaft is sunk on an anticlinal crest, where the measures are nearly flat, as is frequently the case, the work is useless; and it is not always possible, even with the aid of exploring pits, to be certain of starting in the right locality, since those "troubles" do not always betray their existence in the upper strata. As we before stated, the sedimentary deposits are always thickest in the depressions, and the consequence is, that anticlinal cones of small elevation are soon covered, and the upper strata are not affected or folded by them. We do not write this to discourage the development of the Richmond coal-field, but to put capitalists on their guard. We think there are few coal-fields more inviting to the miner than the Richmond basins; but there are none where skill and engineering talents are more needed to insure success. Success, however, is certain to those who go prudently to work and develop with sound judgment. Our sections will convey a good general idea of the formations; but we do not pretend to show the numerous undulations or "troubles" which exist within the principal basins.

The Midlothian and Clover Hill mines are the principal works on the South Side at present, or which were in operation on that side of the James River at the commencement of the war. The celebrated Black Heath had been worked out and abandoned some years previous. The area between these points has not been proved; though coal is supposed to exist in irregular basins almost the entire distance.

Though these mines have been worked more or less for a period of fifty years, but a small portion of the coal-field has been exhausted. Between the Midlothian mines and the James River the measures are much disturbed by the dividing anticlinal, and the change in the nature of the coal and the order of its stratification. The main bed of the south basin either splits into several smaller seams, or a new order of stratification takes place, as represented in figure 135, which is a vertical section of the measures in the basins of the north side. But the change, as before observed, takes place some two miles or more south of the river.

Through the omission of some of the figures in this section (figure 135), the thickness of the measures is not generally given. The general depth of the north-side basins is less than those of the south side, and may be estimated from 500 to 800 feet. But there are exceptions; and we have no doubt the depth of the basin at Dover, on the west, is fully 1000 feet.

It will be observed that the order of stratification in figure 135 is quite different from that of figure 134, representing the south side, and not only the order of deposit is different, but the whole character of the formation differs. There nothing but a coarse quartzose sandstone, intercalated with slates, overlies the coal; but here we find iron ores, trap, coke, &c.

The lower bed in figure 135 is iron ore, and lies some 50 feet above the granite, the character of the intervening space not being developed, but believed to contain only small seams of coal intermixed with slates and coarse sandstones. This bed of ore ranges from 2 to 8 feet in thickness, but is very lean, and contains but a small percentage of metal,—not over 15 or 20 per cent.

FIG. 135.

The second seam in ascending order is a regular seam of bituminous coal, ranging from 5 to 10 feet in thickness, but is very much injured by the numerous small bands of bone and slate which are mixed through the coal, and which it is almost impossible to separate by the means ordinarily in use at those mines. The coal, however, is good, and might be separated from impurities by proper care and mechanical arrangement.

The third seam is much better in character than the former, and contains much less impurity. Its usual size is 4 feet. The fourth seam is also a good workable coal, ranging from 5 to 7 feet thick, and produces an excellent article of fuel. It is, however, streaked with bone and slate, but not to the same extent as the lower seam, and perhaps not to a greater extent than many of our workable beds in the older and more regular coal-fields.

The fifth seam is a bed of *natural coke*, ranging from 5 to 6 feet in thickness. The seam originally appears to have been less mixed with impurities than any of the underlying beds, since the coke is singularly pure and excellent. In appearance it is very much like the artificial coke formed from a rich caking bituminous coal; and in character it is a true carbon, containing the same constituencies as an artificial coke after being exposed some time to the weather, or common red-ash coal of the anthracite mines. It has less lustre than newly-broken artificial coke, and its fracture is more like that of bituminous coal,—though it sometimes tends to the conchoidal or irregular. There are two or three varieties or grades of this natural coke in the same seam, and often within short distances. The most valuable is denoted as "soft or free-burning coke," and the less valuable as "hard or popping coke," from its tendency to fly and "spit," like hemlock or spruce wood, on a fire. The soft coke burns beautifully, and much like good red-ash anthracite; but the "hard coke" ignites with difficulty, and burns slowly unless under a strong draft. The gas or moisture which it contains does not readily escape on heat being applied, owing to its hardness and density, but, on expanding under the heat, bursts its cells and scatters pieces of the coal around, often with great violence.

VERTICAL SECTION, NORTH SIDE RICHMOND COAL-FIELD.

About 60 feet over this bed of natural coke lies a "whin rock," having all the appearance of trap, or basalt, and is of excessive hardness. The strata in its vicinity have a reddish appearance, as if altered by heat; while the next seam above it, and only divided by a few feet of fire-clay, is a perfect *cinder*, and entirely valueless. The seam containing the cinder appears to have been about four feet in thickness, but is now much mixed with fire-clay and iron and sulphur balls. The whole appears to have been changed by intense heat, and the carbon of the coal entirely expelled, leaving the cinder in irregular masses, mixed with the clay, sulphur, and iron balls.

There is no evidence externally of volcanic eruption; but there can be no doubt of the fact that this "whin rock" is a formation of subsequent era, and, instead of being ejected at right angles through the measures, it found a more easy exit between them, and under the bed of coal which it has so singularly changed.

We are not sure that this bed of whin rock extends unbroken through the east basins on the north side, but it is found on the south side of the river, north of the anticlinal before mentioned. It has only been found in the basins of the east side, in the north end of the field, and is not found at Dover, on the west side.*

It is developed extensively at the Carbon Hill mines, on the east side of the basin, but has not been found on the west side. In the deeper portions of the basins the coke depreciates in thickness, and the lower part of the seam is a semi-anthracite, while the coke is "soft," but excellent. There are two beds of thin iron-stone over the "cinder" bed; but they are poor and unreliable, and not of any commercial value.

The measures of the north end of the field are made up chiefly of slates and shales; but several massive rocks of coarse quartzose sandstone are stratified through them. The material filling the basins of this coal-field evidently came from the surrounding country,—chiefly from the higher grounds up the rivers,—and are not the result of volcanic eruptions, as are the measures of the great Appalachian fields generally.

The fossils found in the measures incline naturalists and geologists to place this formation in the Jurassic or oolitic periods; but there is some doubt as to its exact place in the scale of creation. We think there can be no doubt of its late origin; but throughout our labors we have found but little aid as to the identity of coal-beds, or coal measures, from the fossils they present. We do not profess to know enough of fossil botany to depend on our own judgment, and nothing definite enough has yet been developed by the labor of others to be of any certain value at the present time of writing. We hope, however, that the time is not far distant when

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* By the South Side is meant that side of the James River.

the geologist will read the pages of nature, as written on the rocks, as correctly as we now comprehend the wonderful leaf-like pages those rocks represent in the lithological foldings of the earth's crust.

The only operations of note conducted in the Richmond coal-field before the war were the Midlothian and Clover Hill mines on the South Side, as before mentioned, and the Carbon Hill and Dover mines on the north side. The Dover mines were worked on an exceedingly limited scale, by two or three parties. There were also several very small operations conducted in several other localities,—on the south bank of the James River, near the Danville Railroad, in the vicinity of Black Heath; but the amount of coal produced was very limited, and the total amount mined in the Richmond coal-field did not exceed 100,000 tons per annum at the commencement of the war.

We think this amount per annum will cover the entire production of the Richmond mines for the last 50 years, as an average, though we believe 250,000 tons have been mined per annum during a few years. No regular record has been preserved; but the amount raised between the years 1822 and 1841 amounted to 1,750,000 tons, or 87,500 tons per annum; and we do not think the entire amount raised to be over 5,000,000 tons in the aggregate.

The cost of raising this coal, exclusive of mining improvements, has not been less than $2.50 per ton, and, including its delivery in Richmond, about $3.50 per ton. The prices there, from 1850 to 1860, ranged, for "run of the pit," from $4.50 to $5.00 per ton, and for best household coal, from $6 to $7.

There is only one mine operated by improved machinery, including pumps, but not including the ordinary fixtures for delivering the coal from the mines to the surface. This is the Midlothian mine, where, at a late day, when nearly all the coal accessible to the pit had been extracted, an immense and complicated Cornish engine was erected at a great expense,—we think $70,000,—when one of the common "Bull engines," or a good high-pressure, costing less than one-third of this amount, would have been more available. We merely mention this to show the want of practical knowledge in mining matters displayed by the miners of that district. All the other mines are drained by the old-fashioned bucket, and the coal raised in small "bogies," or "coaves." The pits are of small diameter, and will not admit of double hoisting-ways with ordinary cars. The Midlothian pit is over 750 feet deep to the sump, or 722 to the coal, which was 36 feet thick when struck.

This is the deepest pit in the coal-field; and including the dip-workings to the basin, 150 feet, by slope, the total depth from the surface is 900 feet.

The Black Heath and Clover Hill pits are from 500 to 700 feet deep, the Carbon Hill from 150 to 450, and the Dover from 100 to 400.

There is one slope at Trent's mines, near Carbon Hill, which is about 1800 feet in length, and 700 feet perpendicular, but which has been abandoned for some time, on account of the difficulties with the air and water.

The mining operations in the Richmond coal-field have been generally of the most primitive character, and may be referred to the early days of the elder Stephenson in England. Instead of improving and progressing, they have gone backwards for the last ten years, and are now less able to mine coal with economy than they were 20 years ago. Most of the proprietors insist on the bucket being the best and cheapest mode of drainage, and keep on *raising water instead of coal. Cui bono?*

Great and permanent injury has been done to a large portion of this coal-field by the numerous small pits sunk along the outcrops of the coal to the depth of from 100 to 200 feet. From these most of the available upper coal has been excavated to an irregular and uncertain extent, and frequently by dip-slopes from the bottom of these pits to indefinite depths. Those mines have been long abandoned and the excavations filled with water; and, as no records are kept of the direction and extent of those old workings, it becomes dangerous now to approach them from the deeper pits, which, of course, now yield all the available coal.

THE PIEDMONT COAL-FIELD.

This small deposit of coal lies west of the Richmond coal-field, as located on the map representing it in connection with the Richmond coal-field. It exists in the counties of Prince Edward and Cumberland. The formation extends from a point near the James River across the Appomattox at Farmville, and in all probability extends in connection with the Dan River coal-field. But the coal has only been developed in workable seams near Farmville, or in the vicinity of the Piedmont mines, as located on the map. The area of coal is small, and probably does not extend over 20 square miles in the vicinity of Farmville. The formations undulate excessively; the basins are irregular, and the dips to all points of the compass. The bottom rock, resting on gneiss, is a coarse quartzose sandstone, of considerable thickness in the centre of the basins, but quite thin on its edges, where it crops out between the coal and the gneiss. We think this field the creation of a period following the Carboniferous, and earlier than the Richmond period, but formed in much the same manner and from the same materials. The field, however, has been much more disturbed by the subsequent action of the volcanic forces than the Richmond. Numerous dikes and outbursts of trap rend the measures and divide the basins; and only a small portion of the coal is workable, in consequence.

The seams in this field are very thin, and would not be considered workable in the anthracite regions of Pennsylvania. They range from 6 inches to 30 inches. Of those above 12 inches there are 7 which have been proved, in about 300 feet of measures, and lying, perhaps, 300 to 500 feet above the gneiss. The seams which have been proved in the vicinity of the gneiss, at the eastern edge of the coal-field, are very irregular and impure, frequently changing to impure anthracite in localities; while the coal generally is a dry bituminous, containing much sulphur and impurity, coking with difficulty, but producing a hard coke under a strong heat in the coking-ovens. Nothing but white, brittle cast iron can be produced with this coke in the cupola.

The coal is generally hard and difficult to mine; the seams not only thin, but frequently interrupted by "slip dikes," "upthrows," "downthrows," and rock faults, as detailed in Chapter XIV.

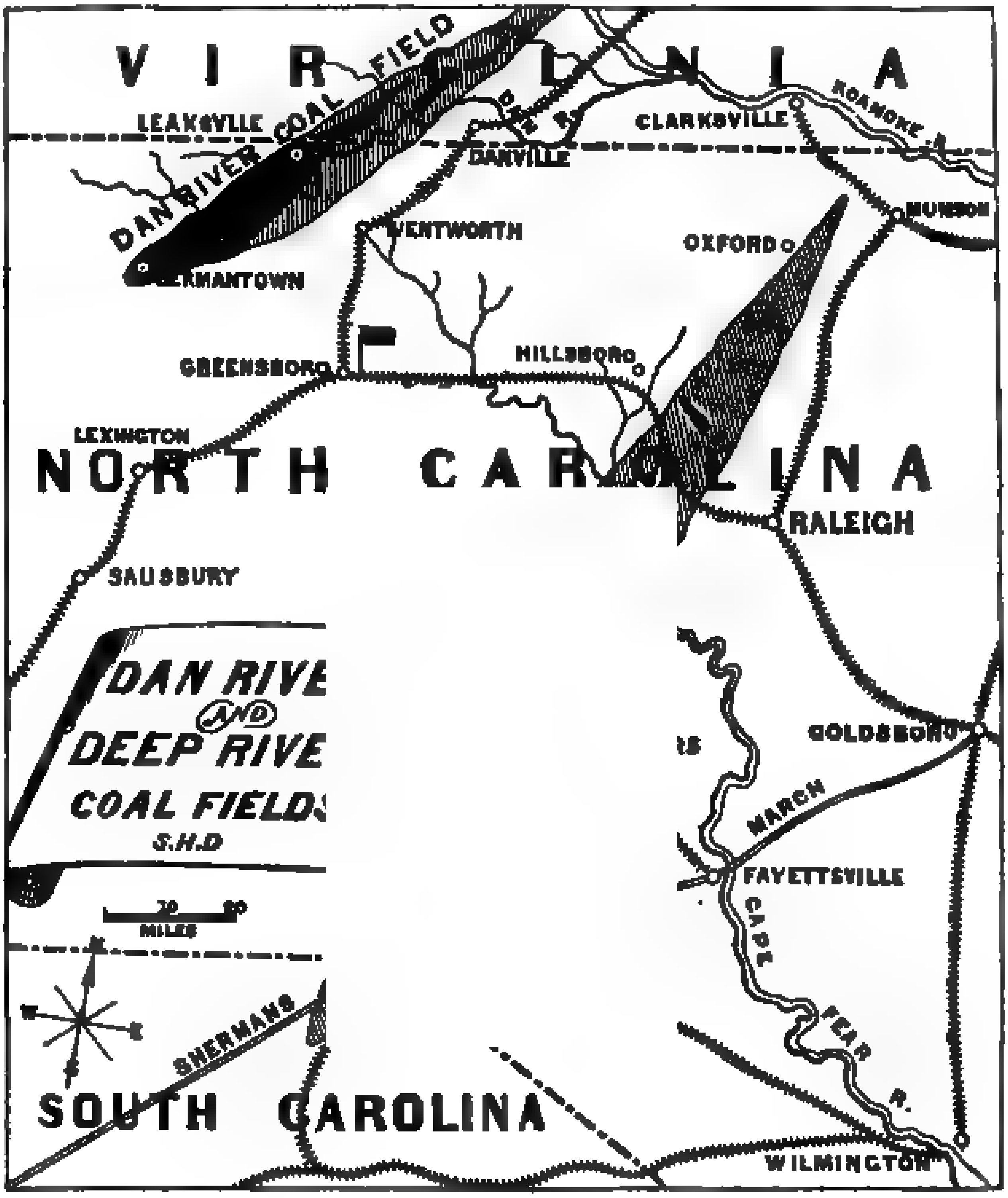
This field has been developed within the last ten years, and only one operation or mine has been worked for local consumption, which, though conducted on a small scale, was the most systematic in Virginia or the South, having complete arrangements for pumping and hoisting: yet, owing to the smallness of the seams, the cost of mining was not less than $2.50 per ton delivered at the top of the mine.

The locality of this small coal-field, in the midst of a thickly-settled inland district, remote from other available coal, will make it valuable for domestic purposes only. In the vicinity of the Pennsylvania anthracites or the Alleghany fields, it would not be considered at present workable.

THE DAN RIVER COAL-FIELD.

This is a small and unimportant deposit of coal, in the vicinity of Danville and on the Dan River, crossing the line between Virginia and North Carolina. It is in all probability a continuation of the Piedmont coal-field, since the size of the seams, the character of the coal,—sometimes changing to anthracite,—and the similarity of the measures all coincide to prove this identity; while the lines of strike are in the same direction. The space between these coal-fields has not been explored; but the occasional appearance of the coal measures leaves little room for doubt as to the connection. But, as before observed, only a small portion of the coal formation contains workable seams, and this applies as strictly to the Dan River as to the Piedmont deposit. No developments have been made in this district of a practical nature, and we have heard of no mining operations being conducted, though coal is much needed at Danville and vicinity. The extent of the Dan River field is limited, and not much greater, in all probability, than the Piedmont, or from 20 to 30 square miles, though the formation covers a comparatively large extent of territory. It does not

seem to be so much disturbed by the infusion of trap as the Farmville extension; but otherwise there is but little difference.



THE DEEP RIVER COAL-FIELD.

The Deep River coal-field lies principally in Chatham county, North Carolina, and on the Deep River, which is the south branch of Cape Fear River. The coal-area, as far as developed, is limited, and less in proportion than represented in our map,—perhaps not over 60 square miles; but the probability is that the coal exists in a great portion of the formation, which extends from Oxford, in North Carolina, to a point near Cheraw, in South Carolina, a distance of 100 miles or more, while its maximum width is about 10 miles; but the floor on which the *coal measures* rest, and which

is so distinct from the gneissic rocks in which the coal-field rests, is very thick. Professor Emmons estimates the floor at 3000 feet in thickness. This floor, or foundation strata, are of recent formation, compared with the gneiss in which it is laid, and evidently has been the wash of higher grounds deposited by water in this deep basin,—too deep, in fact, to admit the growth or formation of coal until this deposition had been made. Though this coal-field may be of nearly the same age as the Richmond coal-field, or of cotemporary existence, and may have been formed in nearly the same manner, the difference in depth of the original basins would effect the difference in stratification which we find here. In the Richmond coal-field we find a *medium depth*, or that depth most favorable to the production of coal, as stated in Chapter XIII.,—that is, about 1000 feet, or from 500 to 1000 feet. But in the Deep River basin the original depth must have been 5000 feet or more: hence we find that no coal was produced until at least 3000 feet of sand and slate had been brought down from the mountains by the numerous streams and deposited as a floor in this deep basin.

Unlike the Richmond field, this floor is consequently uniform and even, and the coal is stratified in thin seams uniformly through it, instead of existing in thick masses in the depressions and disappearing on the elevations; and, though the coal-seams of Deep River are comparatively thin, that field contains as much coal to the acre, in the aggregate, as the Richmond field. The Deep River coal measures are similar to the Arcadian, except in the absence of limestone.

This great *floor* formation of the Deep River field is made up of conglomerates and sandstones chiefly. Some of these sandstones are fine-grained, and others are coarse, depending on the time of their deposition during periods of quiet or commotion. They are occasionally red, having been changed by heat, apparently, as the coal in the formation above is frequently changed by heat from a bituminous to an anthracite.

On this floor the coal measures proper are deposited. They consist of alternating strata of black, carbonaceous slate, shales, and fossiliferous sandstones, about 1000 feet in thickness, in which five or six seams of coal are stratified, respectively from 6 inches to 6 feet in thickness. Over the coal measures, according to Emmons, there are from 2000 to 3000 feet of barren measures, composed of red conglomerates, red and green shales, slates, &c. We think there must be some mistake in estimating this enormous thickness,—which, in the aggregate, makes 7000 feet of sedimentary strata deposited in the basins of Deep River, and 4000 feet as the depth of the Central coal-basin; which is deeper, in all probability, than the existence of any coal. Should this be the fact, the coal-seams of this field will *thin* as they descend, and disappear in the deeper portions of the field.

At Egypt, on the Deep River, south of Haywood, the coal has been cut

by shaft at a depth of 360 feet. The largest seam appears to be in the upper portion of the measures, and is about 5 feet thick, generally. It is a rich bituminous, cakes, and consequently cokes easily, and is said to be free from sulphur, but produces white iron in the blast-furnace. The lower seams produce a semi-anthracite occasionally; but whether this is peculiar to certain portions of the field, is not yet ascertained. In fact, the developments are meagre, and but little, practically, is known concerning the resources of this field.

Iron-ores of several varieties are found in the coal-field and its vicinity. Those in the field are carbonaceous, argillaceous, and sulphurets, and those in the vicinity are red oxides and magnetic. The seams of ore are thin, but frequently rich, and might be put to great advantage in the manufacture of iron if the coal can be used in the furnace. This, however, has not been fairly tested; but it is our impression that none of the Southern coal will make good iron in the blast-furnace, and our experience in this matter entitles the opinion to some weight. The ores of North Carolina and Virginia are rich and plentiful, and, with pure fuel, produce the very best of iron; but the coal generally is impure, and cannot be used successfully in the blast-furnace. But the Southern coal can be profitably used in the production of iron from those rich ores otherwise than in the blast-furnace, since wrought iron can be economically made by several methods in which the coal and the ore do not come in contact, as described under the consideration of iron in another portion of this work. No coal exists suitable for use in the blast-furnace south of the anthracite fields and east of the Alleghanies,—including the Broad Top and the Cumberland coals. Attempts were made during the war to use it, but in all cases, as far as we have heard, without success. All the iron produced in the South, with the exception of that made in some portions of Tennessee, Kentucky, and Missouri, or in the region of the true coal-fields of the Appalachian formations, has been made with charcoal. A large iron-making establishment, including furnaces and rolling-mill, was erected in Chatham county, North Carolina, but had not fairly got into operation when the war, which it was built to support, proved its destruction. We understand it was destroyed by Sherman's boys, as not required by the United States Government!

THE NEW RIVER COAL-FIELDS.

These coal-fields are located principally in Montgomery and Pulaski counties, in Southwestern Virginia, and on the waters of the New River, which is a continuation of the Great Kanawha. The formation of which these fields are parts is very extensive,—apparently of equal extent to the vast area of the Appalachian formations, or the Vespertine period of the Palæozoic strata. It undoubtedly belongs to the proto-Carboniferous, or

lower coal measures, and is, consequently, older than the true Carboniferous of the Alleghany and the Western coal-fields. Its place is between the red shales of the East and the Old Red Sandstone, or in the Vespertine of Rogers, and below the Mountain or Carboniferous limestone of the Western formations.

The outcrops of this strata, and frequently its accompanying thin seams of coal and carbonaceous shale, can be traced from the Sharp Mountain, and the northern limits of X, or the Vespertine, to Tennessee, south of which it does not come to the surface, as far as our experience goes. It has been picked and pried into at many localities, and occasionally thin seams of crushed and impure coal are found, generally anthracite in character, but too impure, irregular, and thin to be of any certain commercial value, except in the single instance of the New River coal-field, where it has been developed in several beds of workable coal, partially anthracite. North of Harper's Ferry, on the Potomac, this formation seems to lie west of the Great Valley; but on crossing the Potomac it enters the valley known as The Valley in Virginia, and is found along its western border, at the foot of the North Mountains, and in close proximity to the limestones, where the eastern outcrops of the overlying strata are inverted. Various attempts have been made to mine this coal, on the Juniata, in Sidelong Hill, near the Potomac, at the "Dora Mines," on the north branch of the Shenandoah River, in Augusta county, Virginia, at the "Catawba mines," near Fincastle in Botetourt county, at the Price Mountain and Brushy Mountain mines in Montgomery county, and many

points farther south; but we do not know of any successful mining operations except those in Price's Mountain and the North Mountain in Montgomery county, Virginia, and near the New River.

Here the coal is found in two parallel basins, of limited extent, but of considerable depth. Price's Mountain basin is perhaps a thousand feet below water-level, while its highest bed may be found over 500 feet above it. The strata dipping to the east—or nearly so, as the "strike" is northeast and southwest—have a gentle inclination of about 25°; but the west dip is *inverted*, with an angle of 75° to 80° east. The North Mountain basin has the same gentle east dip and the same abrupt and inverted west dip; but the basin is not as deep as that of Price's Mountain, and the coal is a semi-bituminous, instead of an anthracite, as it is in the former.

Both basins are narrow, single troughs, not over 1000 feet wide, except at the southern end of Price's Mountain, where the measures are "tumbled" or crushed, and dislocated, and the coal worthless. But all these formations partake of the inverted feature peculiar to the Eastern Palæozoic strata, so fully developed in the anthracite formations; and much of the coal even here, where it exists in its most favorable condition, is crushed and destroyed as an article of value. The crushing forces of the lateral contraction which folded the lithological structure east of the Alleghanies in sharp and oft-repeated axes have been powerfully exerted in this region, and not only crushed and disturbed the coal-seams, but so disarranged the regular order of the strata that much labor and study is necessary to unravel it. But here is the proper place to study those peculiarities, which extend to so great a limit and shroud in doubt so many of our geological problems. The writer spent several months in this locality during 1858–59, and has found the lessons there learned of much value to subsequent investigations throughout the extended line of inverted Eastern strata.

There are three principal seams in these coal-fields. The lower bed ranges from 2 to 4 feet in thickness, and contains about two-thirds its dimensions of pure coal,—anthracite in Price's Mountain, resembling the red-ash of Schuylkill in character, but in appearance more like the splint of Kanawha, but semi-bituminous in the North Mountain, with much the same appearance. This coal is remarkably free from sulphur, but contains much earthy impurity, averaging from 10 to 20 per cent. of ash. It burns beautifully, and makes a lasting rather than a hot fire, except under strong draft. The next or middle bed ranges from 6 to 10 feet in thickness, and produces about one-half its dimensions in available coal, rather softer than the lower bed, and more "shelly" in character and appearance, but in fracture and uses much the same. It is about 50 feet above the lower, and divided by coarse flags or laminated sandstones and slates. The upper bed has not been developed to any extent, but it contains less available coal than the middle bed, and is of a softer and more unreliable character.

All these beds are subject to frequent changes, resulting from original imperfection or subsequent crust-movements. "Dirt faults," "slate faults," and "rock faults" are common occurrences. The dirt and slate faults are in the usual form, as shown in Chapter XIV. The rock faults are slip dikes, or "upthrows" and "downthrows," and are frequent and serious impediments in the way of mining operations. Sometimes the beds are thrown down 20 or 30 feet, and in a few yards thrown up again 10 or 15. Several mining operations on a small and primitive scale are conducted in these coal-fields. In Price's Mountain basin, a slope, known as Kyle's mines, was sunk in 1857–58 to the depth of 150 feet, and considerable valuable coal extracted. We believe those mines are still in operation. The other mines are small drifts or tunnels in the North Mountain, —the whole productive of less than 10,000 tons per annum.

The extent of this coal formation, as before stated, has a wide range; but its outcrops are better developed along the eastern front of the Alleghany ranges, or the mountains parallel with the Great Valley range, than elsewhere. Though open at many points, and productive of valuable coal-beds at but few, this formation, under future developments, may be of great value to the districts through which it ranges, as an article of fuel when the country becomes more thickly peopled. It lies parallel with, and in close proximity to, the richest and most productive district on the Atlantic slopes,—the Great Valley range; and, though the coal may be impure and the beds uncertain, a great amount of valuable fuel may be obtained cheaper than it can be transported from the more reliable but distant coal-fields of the North or West.

In the New River coal-field, which is part of this proto-Carboniferous formation, a bed of *pea* conglomerate exists in its natural position as the floor of the coal measures. It ranges from 10 to 30 feet in thickness, and is so nearly like the conglomerate of the eastern margin of the Great Alleghany coal-field, that, were the other conditions identical, we should not hesitate to pronounce it on the same horizon and the production of the same era. But since the red shale is over the coal measures, and the fossils those of the Subcarboniferous, we cannot assign it to the true coals; while its range is coincident with the lower or false coal measures.

The anthracite of this region has been used successfully in the cupola in the production of castings, but we have not heard of its use in the blast-furnace. We have no doubt, however, of its value for such purposes, if divided from its earthy impurities.

The difficulties of mining this coal, and the irregularity of the beds, will always be great, and make the cost much beyond a reasonable limit for the production of iron to compete with other and more favored sections in this respect.

The coal has been used during the war, at Lynchburg and the towns

along the line of the Virginia & Tennessee Railroad, in place of the Pennsylvania anthracite formerly used, for the purpose of producing castings from the cupola or in the foundries; but no pig-iron was produced from the blast-furnaces in Virginia with coal as a fuel.

The ores in Southwestern Virginia, and in the vicinity of these coal-fields, are abundant and rich, principally of the varieties known as the red and brown hematites; but the red oxides or fossiliferous, and some magnetic, also exist. While there may be some doubt as to the propriety of using the coals of the vicinity in the blast-furnace for the production of pig-iron, there can be none in relation to the value of the ores; and the day may not be far distant when enterprise shall open the way for their transit to the magnificent coal-beds of the Kanawha, where iron can be made with the assistance of the ores of the Southwest as cheaply as it can be made in any other part of the world under the same rate of labor.

The coals of this region, however, will find their uses for domestic purposes. The surrounding country is unusually rich and inviting; the soils are productive, and the valleys extensive and beautiful; the climate is delightful, and the scenery charming. It is naturally the richest and most attractive spot, we think, in the Great Valley range, though not so well developed or so wide as in Pennsylvania nor so level and extensive as in East Tennessee. But it is rich in soils and minerals, and located in a high mountain-valley, where the extremes of north and south are modified. Copper, lead, and iron ores are abundant, and only waiting their natural outlet down the New River and through the Kanawha Valley to the great West. Such a development would not only enrich this section of Virginia, but would be of immense advantage to the manufacturing interests of the Kanawha and the valleys of the Ohio and Mississippi.

PART V.

CHAPTER XXIII.

MINING ECONOMY AND VENTILATION.

Open Quarries—Lehigh—Virginia—Alabama—Mining above Water-Level—By Drifts and Tunnels—Proving and Tracing Coal-Beds—Mining below Water-Level—Shafts, Slopes, &c.—Modes of Working and Ventilating Mines—Plane—"Run"—Fan—Boundary System—Pitching Seams—Economy—Waste of Coal—Improved Methods of Working and Ventilating Mines—Flat Seams, or Low Angles of Dip—Ventilation—Economy of Mining—Safety to Life and Health—System.

We have endeavored in the preceding chapters to give a concise account of our coal-fields and their peculiarities,—to present in a practical and comprehensive manner the chief points of interest or value to the miner or general reader in regard to the extent and character of our coal-fields and the form and position in which their beds are stratified in the earth. The purely scientific may not derive much benefit or be much interested; but to them also we present many facts and useful hints, that may lead to more definite conclusions and more satisfactory results than the numerous theories now extant in regard to coal and its formation. In the following pages it is our purpose to present, in the plainest manner possible and as concisely as we can, the *economy of mining* practically considered and as a science, including the excavation or mining and raising of coal, and the drainage and ventilation of deep mines.

"DRIFTS," OR WATER-LEVELS.

Fig. 186.

DRIFT.

The first mode of mining coal was by open quarry, or by uncovering the coal-beds where they approached the surface at their outcrops, and extracting as much of the coal as possible until prevented by water or the increasing thickness of the covering earth. The most remarkable instance of mining by "open quarry" was at the old Lehigh Summit mines, during the early days of the anthracite coal-trade (see figure 15), where the outcrops of the Mammoth presented a mass of coal nearly one hundred feet thick, covered by a small amount of earthy surface.

In the Richmond coal-field numerous excavations of this kind are found along the outcrops of the seams, and, in some cases, immense quantities of earth have been removed to obtain a small amount of coal. In Alabama the writer witnessed this mode of obtaining coal within the last five years, where the negroes were removing *thirty feet of cover* to obtain *four feet of coal;* while the seam was finely exposed in the side of the hill, where the coal could have been obtained with one-tenth the labor by the ordinary process of "drifting" on the seam. But in all countries this style is always the first adopted. We presume, however, the development of the Southern coal-fields to be behind that of all other countries, as there neither skill nor science has aided brute force with any degree of intelligence.

The first regular system of mining generally adopted is "drifting" or tunnelling on the "strike" of the seam, in all coal-fields where the seams are found outcropping in the hills above water-level. But this mode can be used only when the beds are exposed by denudation, beneath their horizon when flat, or beneath their line of strike when pitching. Drifts differ from tunnels, inasmuch as the former enter the seam and follow it; while the latter generally cross the measures at right angles with the seam and penetrate the rocky strata to the coal.

In the anthracite regions, drifts are generally used above water-level, entering the seams where cut by the water-courses; but where the seams are not thus exposed, they are cut by tunnels, and the coal worked at right angles to the same by "gangways." This term (gangway) is also applied to the drift after it has entered the bed a sufficient distance to admit of chambers or "breasts" being "turned." All the main avenues of the mine through which the coal is conveyed from the chambers are known as gangways. The English miners call them main-ways, rolley-ways, &c.

To explain more clearly to the inexperienced, we give the following illustration, figure 137, showing the outcrop, strike, water-level, and dip, which, in connection with the accompanying representations, will fully express the position of coal-beds and the modes of entering them by drift, tunnel, slope, or shaft.

In figure 137 the coal above the *water-level* line may be reached by drift from either side of the ravine or water-course denoted, and on a level with the stream. The *strike*

FIG. 137.

STRIKE, WATER-LEVEL, OUTCROP, AND DIP.

of the outcrop, or course of the seam, is indicated by the straight arrow; while the actual outcrop is shown by the bent arrows in the coal. The intervening space is denuded by the action of water,—both coal and coal measures having been swept away. The dip of the coal is denoted by the word in the engraving, but is more clearly expressed in the following cut,—figure 138,—which shows the outcrops from an end view, instead of the surface view in the preceding.

The action of the water, as shown in the foregoing figure, enables the miner to enter the *coal* on its strike at water-level. If not thus exposed, it could only be opened by tunnel across the measures, in order to effect its drainage and obtain the coal without the use of steam-power.

This form of exposure is peculiar to pitching seams and hilly districts. In districts

or fields where the coal is horizontal or nearly so,—for instance, as represented in figure 123, Kanawha region,—the effect of denudation is quite different, and the seams can be entered at almost any point on the sides of a mountain. Tunnels cannot be used; and, when the denuding waters have not cut down the measures and exposed the seams, shafting alone can be resorted to.

But we must follow the original development of coal further, before explaining the more advanced modes.

Figure 138 explains more fully the outcrops of pitching seams, and the mode in which they may be found and proved on the surface by means of a "trial-pit." The indications of coal are unmistakable to the practised eye, and any good practical miner should know the difference between *coal measures* and ordinary strata; but even the most experienced cannot always tell the exact spot in which a seam of coal may be found within those measures. The surface is generally covered to a considerable depth by debris or

FIG. 138.

OUTCROPS AND PROOF.

wash from other material than that near the coal, and it requires some skill to locate the positions of the seams, and frequently some digging; but when once located and proved, as shown in the preceding illustration, the tracing of the respective seams along their outcrop or strike is not a difficult matter. In the anthracite regions the lower series, or white-ash beds, can generally be traced by the accompanying rocks, which are peculiar and always in place. The conglomerate always lies below the lower bed, and frequently between the lower coal-strata; while a heavy, coarse sandrock overlies the Mammoth But this large bed, lying between those massive rocks and exposing its slates and outcrops frequently, is not easily concealed from the miner. The upper seams are more difficult to find; but, knowing their respective distances from some well-known rock or bed, it is only a matter of patience and time. They can always be opened by the *pick* and *shovel* with a little labor; and the tracing from point to point can then be done by the accompanying surface slates or rocks, by noting the dip and course, and following by compass, by tracing with an auger, by light surface-shafting, or simply by the *eye* and *mind*.

But in some coal-fields there is more difficulty in finding the coal and tracing the seams. In the Richmond coal-field, where the surface is covered with sand and the debris of distant and foreign strata, where the coal measures consequently are concealed, and where the seams are irregular in both dip and strike, nothing but actual proof by shaft or auger will be available. But in the Western coal-fields, where the measures are cut down by streams, the discovery and tracing of the coal-seams are matters which require little experience or skill.

SHAFTS, SLOPES, TUNNELS, ETC.

In the accompanying illustration, figure 139, we present the various modes of mining as pursued in the anthracite coal-fields. The deep, abrupt basin of coal on the left is opened by slope, *a*, *a*, in preference to any other mode, as the simplest and most available. The position of the seam, dipping at an angle of 60°, in which the slope is sunk, would indicate it to be the Mammoth. The basin of this seam is reached by the second "lift" in the slope. Each "lift," of one hundred yards' depth, is denoted by a tunnel, *c*, *c*, driven to cut the overlying and underlying seams. From the

Fig. 139.

COAL-MINING.

basin of the Mammoth the slope is continued another "lift"—the third—across the measures to the basin of the Buck Mountain bed, or B; and by this means the entire basin is exhausted with much economy, and in less time than it could be made available by shaft.

To the inexperienced this may require a little more explanation. The upper or water-level portion of the seams here denoted is marked out by means of drifts, *d*, which may be estimated as starting at water-level, and 300 feet from the outcrops, below the engine-house. The first lift of the slope is to tunnel No. 1, 300 feet below the water-level line; the second lift is to tunnel No. 2, or the basin of the seam in which the slope is sunk, which is about 300 feet below the line of tunnel No. 1. The third lift is from the basin of E to the basin of B, and may be 300 feet. This would make the length of the slope from the landing in front of the engine-house 1200 feet long to the basin of B; but the water would only be lifted 900 feet, or to the line of the water-level, and by three "lifts." The term "lift" is given to denote the distance which the water is lifted by each set of pumps. It is found by experience that 300 feet perpendicular is about the maximum height for a column of water to be lifted by pumping machinery; if a mine be 500 feet deep, it is better to divide the column in two lifts than to attempt to lift it in one column. The word *lift*, therefore, has become a technical phrase to denote, not only the distance which the water is lifted, but also the extent of "breast" found most available in our present mode of mining anthracite coal. It will be noticed that all the coal of the left basin can be obtained by means of this one slope, and the tunnels which are driven to the different seams.

The right basin, however, being wider and more shallow, while the bottom is comparatively horizontal, can be mined by shaft with more economy and availability than by any other means. The distance from the surface to the lower big vein, or B, under such circumstances, would be about 600 feet, and that to the Mammoth, or upper big vein, E, 350 feet. In all shallow basins, where the coal has a low angle of dip, and the basins are consequently wide, shafting is the most available mode of reaching and mining the coal.

In this basin, both drift and tunnel are used to obtain the coal above water-level. The position may be such that drifts cannot enter the seams at water-level, and a tunnel is then resorted to; but the distance from the tunnel *c*, *c*, to the outcrops of the seams is too great to be mined economically by one set of breasts or chambers, particularly when the angle of dip is as low as here represented,—30°: therefore a "counter-level," or drift, *d*, is driven into the seam between the tunnel and the outcrop, and the coal brought down to the level of the tunnel by inclines. The position of the coal-breakers and outside improvements is denoted by the buildings in connection with the respective basins. This illustration, if properly understood, will convey a better impression of the modes of mining generally in use than could be given by pages of description: we therefore briefly call attention to the letters in the engraving, and leave the reader to "find out" what we may have omitted. A glance will be sufficient for the practical to comprehend the whole.

MODES OF MINING AND VENTILATION IN USE IN THE ANTHRACITE REGIONS.

It has been often said, and frequently most obstinately argued, that the modes of mining adopted in the anthracite regions of Pennsylvania were the necessary results of the peculiarities of the region, and that the improved systems of the English miners cannot be profitably introduced. We have invented a style peculiarly our own, and no attempts have been made to improve it: and that the general system is correct we have little room to doubt; but that it cannot be improved, we think a serious mistake, and one that is causing a loss of millions of tons of coal per annum to the landed proprietors, and perhaps as many millions of dollars to the operators or miners. The English system, which is generally used in horizontal seams, will not do for direct importation here; but a modification (?) of the two systems can be made available, and effect a decided improvement in our styles of mining and in the economy of coal and its production.

We will first give a page-illustration of the various plans now in use in our mines; and, instead of giving them in separate engravings, we have given seven plans in one illustration, for two reasons. First, our deep basins do not carry one invariable dip: we have seen them vary from 5° to 30° in the same seam: consequently, nearly all the plans represented are frequently required in one mine; and we give them also to show their absurdity. Second, the mode adopted brings the several plans before the eye, and enables us to present them comprehensively.

We will first explain the mode or general style here adopted, and the necessity for the changes in the modes of mining,—commencing at the shaft *a*. The design is for a large, double upcast and downcast shaft, with double hoisting-ways in each compartment, and ventilated by furnaces, as shown at *b*, or by fan, if desirable.

We assume this shaft to be sunk in the centre or deepest part of a basin, but that this basin is much narrower at one end than the other, and, consequently, that the angles of dip are proportionally steeper: this would necessitate modifications in the mode of mining the coal. At dips ranging from 5° to 30° the coal would not "run" in "shutes," but the cars must be taken in the "breast" to the miner, and the coal taken direct from his hand. But when the dip is over 10°, the cars cannot be taken off at right angles with the gangways or main avenues: they must have an oblique course, in order to overcome the grade. When the dip of the seam is over 30°, it becomes too steep to take the cars into the breasts, and "shutes" are resorted to. These are passages, or "ways," driven at right angles with the gangways, and kept open in the middle or at each side of the breast or chamber; into these the miner throws his coal, which, by its own gravity, slides down to the bottom, where it is loaded into the cars. The difficulties with this mode are twofold: first, when under 30° of dip, the coal will not run freely down the

shutes; and second, when steeper, the miner has much difficulty in taking up his timber and material.

Fig. 140.

BREASTS, OR CHAMBERS.

Figure 140 illustrates clearly the form of the chambers, or breasts and pillars, made use of in all our pitching seams; but the representation conveys simply the idea of the form of breast and pillar alternately. The air-courses, shutes, &c. are not displayed.

In the plan or plans illustrated on page 416 we have introduced what may be called a double set of workings,—one on each side of the basin: consequently, two gangways are shown, and two regular return air-courses, with one inlet air-course. We do not advocate this plan, nor think that all these mainways are required. A single gangway in the centre of the basin would answer for a large business, and for the purpose of an inlet air-course, while the two parallel air-courses would be all that is desirable for the return air, provided such a consummation could be made to work under all the circumstances; but there the difficulty lies. A single gangway might answer where the basin is flat and wide, and where the cars can be taken into the breasts; but in plans 4 and 5 two gangways are absolutely necessary. While the pitch may be steep enough for the coal to "run" on each side, it is not so in the centre: consequently, the gangways must be along the foot of each dip, instead of the centre of the synclinal. The only change that could be made to work this centre basin from one shaft would be to dispense with the middle *inlet air-course*, and with one gangway to the left of the shaft: otherwise the whole complicated system is required to ventilate the works and mine the coal on a large scale. In regard to the plans displayed, it is not necessary that all the modes presented should be used, since Nos. 1 and 2, and 6 and 7, are much the same, and simply ventilated differently and mined in various forms to illustrate the modes in use. Likewise Nos. 3 and 5 are so near alike in practical effect that either could be used in the same place or on the same dip. With this explanation, we may go on to describe the modes or plans as given in the preceding engraving.

PLAN NO. 1.

This is a mode generally made use of in flat seams, or where the dip is about 5°. The chambers are turned off from the main avenue or gangway at right angles, and the railroads for the mine-cars take up one or both sides of the breast or chambers, while the air is carried up one side and down the other. This plan is frequently modified by cutting "headings" from one breast to the other, as shown in No. 7, and carrying the air along the face of each, as shown in No. 2. The arrows indicate the course of the air. This *plan* will come under consideration again in No. 7.

PLAN NO. 2.

This is an offset that becomes necessary from the change of pitch, which increases

from 5° to 10°, as shown by the figures. This mode might be continued through No. 3 with benefit, we think; but, as it is not consistent with the plans generally adopted, we have given those which are. It will be noticed by those who are familiar with such matters, that the change from No. 1 to No. 3 becomes necessary in consequence of the change of dip: while No. 1 runs off at right angles to the gangway, No. 3 runs off obliquely in order to accommodate the grades of the railroads to the dips of the seam. This oblique course leaves an angle or corner which No. 2 removes; and, as it is not desirable to start off chambers of this character near the shaft, a larger corner is allotted to No. 2 than is absolutely necessary. The air from No. 1 circulates through No. 2.

PLAN NO. 3.

The general mode of mining coal from pitching seams which are not steep enough to "run" the coal down the shutes, and yet too steep to take the cars in any direction the miner may choose, is given in this plan. The course of the chambers or breasts, and, consequently, of the tram-roads following them, is at greater or less angles with the gangway, according to the dip of the seam. If the dip is 10°, the course may be nearly at right angles, but if 30°, the course must oblique slowly from the gangway and run nearly parallel with it. This mode, therefore, has serious objections, since no order or system can be continued unless the dip of the seam is uniform, and then no perfect system of ventilation can be preserved in extensive mining. The objections are so numerous that we do not think it profitable to argue them. The mode of ventilation commonly adopted is by "cross-heading" at intervals from one breast to another, or by carrying the air up one and down the other,—both being alike objectionable and dangerous in a fiery mine, from the fact that the gas is carried a great distance with its gathering impurities, past the *face* where the miners are at work, and, consequently, can furnish only impure air to the outside breasts, and may become inflammable enough to ignite from the miners' lamps.

PLAN NO. 4.

This mode differs essentially from those mentioned in the foregoing plans. They (Nos. 1, 2, and 3) require the car to enter the chambers and follow the miner, taking the coal from his hand direct to the surface; but Nos. 1, 2, and 3 can be used to advantage only when the pitch or dip of the seam is below 25°; when it is over that, "shutes" instead of railroads are made use of, as shown in plans 4 and 5. In plan 4 the shute is carried up the centre of the breast. In small seams it is a passage or way about 6 feet wide up the middle of the breast, secured by timber on each side, and against which the refuse of the mine is packed on the outside. An avenue or incline is thus formed directly up the pitch of the seam and at right angles with the main gangway. Into this the coal is thrown by the miners or their assistants, and down the smooth incline formed by the bottom slate of the seam the coal *slides* to the vicinity of the gangway, where it is loaded into the cars. This plan is perhaps improved by that of No. 5, in which the shutes are carried up on each side of the breast and against the sides of the pillars, in which case there are two shutes to each breast, but only the same quantity of timber required, as a single row of "props," parallel with each pillar, is sufficient. In either case the air is generally carried up one breast and down the other, or along the face of the breasts, going up the inside one and down the outside one; but most of the anthracite collieries worked on this plan are small red-ash seams above water-level, and the air in such cases generally escapes through an "air-hole" ascending to the surface from one of the breasts. In large collieries below water-level, improvements are required which will be illustrated farther on. Many of our collieries, however, are

still worked on this principle, and they are, consequently, often troubled with "bad air," and interrupted by falling rock or "crushes" in the abandoned portions of the mine, through which the air is necessarily carried.

PLAN NO. 5.

This mode has several modifications, and may be considered the best in use in the anthracite mines. The illustration conveys but an imperfect impression of this style, and only gives one illustration of it. It may be noticed that the air passes up one shute and down the other in the same breast. This is not the best or the general plan. It is more frequently carried up one breast and down the other by "cross-heading" the intervening pillars. But perhaps it is as usually carried up the inside breast and along the "faces" of the breasts through occasional cross-headings, and down the outside breast. The second plan is better than the first; but between the second and the third there is not much difference. When the shutes are long, foul air is apt to gather in them, unless a current is kept in circulation through them; and in this respect the second mode is preferable to the third; but both are defective, from the fact that the entire impurities of the mine are swept along with the current through all the breasts, and the gathering gases and foul air must accumulate and become obnoxious in the outside breasts. This is the great evil in all our modes of ventilation. The air is carried in an unbroken current through the entire mine, sometimes traversing many miles of air-courses, and carrying the foul air and gases from one breast to the other, from the inside miner to the next outside, to the end. It not only makes the current weak, but it can furnish only impure air to a large portion of the mine.

We have given a part of the excavated portion of the mine, or goaf (gob), in plan 5, representing portions of the pillars "lost;" but this is a favorable exposition. We have no doubt that from one-third to one-half the coal in our large beds is "lost" by this plan of mining; and we cannot see how it can be otherwise, since the immense pillars, except their upper portion, must stand until the entire mine is worked to the boundary before they can be "robbed," or "worked back;" and when this comes to be done, the immense weight of the superincumbent strata brings on a "crush," which ruins most of the coal and prevents the remainder from being obtained, so that none or but little of the numerous and massive pillars left by our present system of mining can be obtained. In both respects,—in ventilation, as well as the economy of coal,—the mode of mining generally in use in the anthracite regions is not only seriously defective, but *wasteful, dangerous*, and *ruinous*.

There are exceptions to this sweeping charge; but they are few and far between, and we have rarely met with a well-ventilated and economically mined colliery in this country,—much to our surprise; since the best of English talent is employed in the anthracite regions, and we cannot accept the maxim that the English modes do not apply to our formations. We hope to prove conclusively that we are not only following the most wasteful, imperfect, and costly methods, but that the improved and long-tried English plans of ventilation and mining can be successfully modified and applied with much economy to our anthracite mines; while for the bituminous regions they are just the plans required.

PLAN NO. 6.

This is a modification of No. 2, to conform to the greater angle of dip, which increases from 5° to 30°. It is the same in principle as No. 3, and is much in use where the angles of dip are within the degrees specified. This and the preceding modes—plans Nos. 4 and 5—are in general use in the anthracite regions, but are both open to the same objections in regard to ventilation and the waste of coal; and no order or system

can be successfully pursued that is not liable to sudden derangement from the frequent changes of dip. The ventilation in plan No. 6 is susceptible of a change from the mode given, which is perhaps the best in works of small extent; but when more extensive the air is taken down one chamber and up the other.

The cars are taken into the breasts or chambers in all such cases: they follow the miner and receive the coal from his hand, taking it direct to the surface. Where the dip is considerable, the railroad (tram-way) is carried on the lower side of the breast or chamber, against, and parallel with, the pillar. If carried through the middle of the chamber, when the dip is considerable it would occasion much labor in handling the coal up from the "dip side," and would also prevent the drainage of the water from the lower side of the chamber; but when the road is carried on the "dip side" it forms an escape for the water, and enables the miner to *slide* his coal down the incline of the seam from the upper portions of the chamber to the vicinity of the car, and thus saves handling. These breasts or chambers are carried from 16 to 30 feet wide, according to the nature of the top and the size and character of the seam.

PLAN NO. 7.

This is a simple modification of No. 1: they are both worked on the same principle. In this case the roads are carried through the middle of the chambers instead of the sides, and the air passed up one breast and down the other; though it is perhaps as frequently carried along the *faces*, by going up the inside breast and down the outside one.

These chambers, like those of No. 1, are taken off at right angles from the gangway or main avenue, and can be successfully used only when the dip is about 5° or less, —which is not of frequent occurrence in the anthracite regions, except in the Scranton district of the Northern coal-field.

Plans Nos. 1, 2, and 3 are much the same, and in use where the dip of the seams is at a low angle. The modifications of these plans in the style of ventilation are as represented. The air is passed from *face* to *face* through the pillars and up one breast and down the other, or up the inside breast and down the outside one,—but always carried in an unbroken current through the entire mine, or that portion of it lying on one side or other of the shaft or slope.

Plans Nos. 3 and 6 are similar to each other, and differ only in the mode of leaving the main avenue. These plans are used generally when the dip of the seams is over 5° or under 25°. They are the most defective modes in operation, and are more liable to interruption and confusion than the other plans given; while the difficulties of ventilation and the waste of coal are equally defective; but in regard to the cost of mining and sending coal to the surface, this mode is perhaps as economical as any other, and much more so than the *breast* and shute method, unless the *pitch* is great enough to admit of the coal running into the cars without rehandling. Nos. 1, 2, and 7 are similar in this respect to Nos. 3 and 6; the former are the most simple, and less liable to derangement, but can be adopted only in horizontal beds, or where the dip is less than 5°. Plans Nos. 4 and 5 are likewise similar to each other, and are simple modifications of the same general plan.

It thus results that there are two general systems in use in the anthracite regions,— one practised in all seams where the dip is less than 25° or 30°, and the other where the dips are above 30°.

In the first, the cars are taken into the breasts or chambers, and follow the miners to receive the coal direct from their hands; in the second, "shutes" are used, down which the coal slides on the inclining bottom slate of the seams, or on sheet iron or plank laid for the purpose, when the dip is not steep enough for the coal to slide readily on the

bottom slate. These shutes either lead direct into the cars, which stand on the main railroad in the gangway, or the coal is rehandled and thrown by hand into the cars. When the seam is large and the pitch steep enough to carry the coal down by gravity, the first method is used; but when the seam is small and the angle of dip low, the second and more expensive method is used.

The system of ventilation is much the same in general principle, whatever plan of mining be used,—subject, however, to the modifications specified. The general and governing principle of the system, and its most objectionable feature, is the circulation of the air in a continuous column or channel throughout the mine, sweeping the impurities of the works before it, and carrying the foul air and accumulating gases from miner to miner and from breast to breast, until they become obnoxious and dangerous.

In an extensive mine conducted on this principle, there can be no perfect ventilation. It is true that a strong current of air can be moved through the mine when the air-courses are systematically arranged and kept in order by mechanical means; and the inflammable gases may be diluted beyond the explosive point; but the powder-smoke from frequent blasting, the smoke and carbonic oxide from hundreds of lamps, the exhalations of the workmen, and the accumulating foulness resulting from these and other causes, must pass from man to man, and render more and more deleterious the impure air they breathe.

But, while this serious difficulty exists in the best-ventilated collieries under our present system, those which are not well ventilated—and they are by far the most numerous—suffer from still more serious and additional difficulties from the lack of such air, bad as it is, and from the constant presence of explosive gases. Thousands of our miners are obliged to work in an atmosphere as explosive as powder, and which the least forgetfulness or accident might ignite with sudden destruction to life and ruin to property. These difficulties and dangers will always exist as long as we persist in following an obsolete and wasteful system.

We will introduce the most improved method that has been, or which can be, adopted on this principle, before we discuss the improvements required by the present wants of the anthracite miners.

"RUN," WITH FAN VENTILATION.

In the plan presented on next page, we have given that which is known as the "run," but do not confine our description of the plan to this mode, since it is susceptible of much modification. The "run" can be used to advantage only when the seams are comparatively large, the dip 40° or over, and the top slate or rock firm and solid: when all these favorable conditions exist, it is the cheapest mode known of mining coal.

There are two or three methods in use. The one represented has "travelling-ways" or air-courses up each side of the breast, which is 30 feet wide. These are kept open for the passage of the miners and the passage of the air. They are secured by leaning timbers against the pillars, or by propping up the top coals and making a passage in the bottom portion of the seam.

The coal is blasted with powder from the *face* of the breast,—often in immense masses when the seam is large, as in the case of the Mammoth,—and falls into the body of the breast below, where it is broken into convenient sizes, and is then ready for the "loaders," who draw it as required into the cars, which stand on the railroad in the main gangway.

The coal when broken occupies double the space it does in the solid: therefore, as the miner progresses with his work, over one-half the coal must be drawn from the breast in order to give him room to work; the remainder is left in the breast, to fill up the yawning gulf which otherwise would exist below him.

This method, known as the "run," is the cheapest and simplest known; but, as before said, it can be used only under certain conditions. If the dip is not steep enough, it will *not run*; or if the roof—top slate—is rotten and weak, it will fall among the coal and ruin its marketable qualities. Under such circumstances, the mode of mining adopted is similar to that described in plan 5, of which, in fact, this is nearly a copy. The coal is then thrown into the shutes, which, when not used for the purpose of sliding down the coal, are called travelling-ways. The space between the shutes, which is filled with coal when worked as runs, is in this plan open and dangerous,

FIG. 141.

PLAN OF VENTILATION BY FAN, AND METHOD OF WORKING BY "RUNS."

or partially filled with *waste coal*, falling slates, and bulwarks, or "batteries" of timber. In both modes the air-courses or passage-ways are often carried through the middle of the pillars, and headings driven occasionally, as required, from one breast to the other.

In the plan presented, the air circulates up one side of the breast and down the other. It would perhaps be equally available to take it up one breast and down the other, or to carry it along the *faces* from one to the other. In this last mode, the air ascends the inside breast, passes through "headings" in the pillars to the succeeding outside breasts, and descends the last outside one to the return air-course *f*.

The inlet air-course *e*, below the gangway *d*, may be dispensed with, and the air taken through the gangway *d* to a point near its *face*, and then passed up the inside shute, as shown in the engraving, to the inside breast *i*. It may then circulate up and down the breasts alternately, or traverse the *face* of each breast, and descend the outside one to the return air-course *f*. This is ventilated by a fan, *c*, near the top of the upcast slope *c*, and may be supplied with more air than is required for ventilation: therefore there is a surplus, and the shutes may be ventilated by "escapes" when desired, provided the mode of "sweeping" the face of the works is adopted. This plan is perhaps the best in use, since the distance to be traversed is less than in other cases; but it is still liable to some of the serious objections advanced against nearly similar modes in considering the plans presented on page 416, while the objections to the waste of coal in pillars remain unchanged.

Having thus briefly described the modes of mining and ventilation generally in use in the anthracite coal-fields, and to a great extent, also, in most of our bituminous fields, we now venture to present a modification of the English systems, as adaptable to the

peculiar anthracite formations; and if we succeed in presenting them clearly and comprehensively, we have no doubt of a favorable result, since the improvement must be apparent to the mind of every practical miner.

BOUNDARY SYSTEM OF MINING AND VENTILATION.

All will admit that the best mode of mining coal, and the most economical eventually, is to extend the workings, main avenues, and air-courses, to the extent of the "run," or boundary of the mine, and then work out all the coal in returning, by the "long wall," "breast and pillar," or "chamber and car" modes of mining.

The expense and time necessary to carry into effect this mode are its great and serious objections, and, in this country, may be considered effectual bars against its adoption. It is in use in some of the English collieries, in Lancashire; but in the great Newcastle coal-field—the oldest and best-developed in Great Britain—it is but rarely, if ever, in use, partly owing to the same objections, but mainly because the system there generally in use presents all the benefits of the boundary system, as adopted near Manchester and elsewhere, and none of its objections; and a modification of this system to suit the peculiarities of our formations in the anthracite regions we now present. But we would here remark that the two plans presented embrace every character of dip, and may be adopted in horizontal as well as pitching seams; or the "workings" of any mine can be changed to this plan with benefit to ventilation and economy in mining.

The plan presented in figure 142 is designed for pitching seams,—say over 30°,—but

Fig. 142.

BOUNDARY SYSTEM FOR PITCHING SEAMS.

may be used for all seams which are steep enough for the coal to run down the incline of the bottom slates without rehandling. All seams which do not admit of this should be worked by the plan represented in figure 144. This plan is equally applicable to shaft, slope, tunnel, or drift, above or below water-level: in fact, these considerations do not affect in any degree the mode proposed. We here present the slope method, as that is generally more applicable to steep-dipping seams than to those of low angles.

The plan represents the second "lift," showing the upper lift "worked out." In this design we present only enough of the mine—say 1000 yards on one side of the slope—to convey an impression of the plan proposed.

The slope and downcast air-course are represented by *c*, and the upcast air-course and pump-way by *d*. The gangway and inlet air-course is *a*, and the return air-course is *b*. The breasts are marked *e*, and the courses of the air denoted by arrows. The breasts communicate with the gangway by means of shutes, which may be one or two to each breast. To this point there is no change from the ordinary methods now in use, which are as simple and effective as can be desired. But, in order to perfect the ventilation and secure the pillars from waste, we have laid out the mine in BOUNDARIES, which may be in small or large proportions, as the extent of the mine or character of the seam may suggest. We propose to make each boundary 500 yards in length, by the full breadth of the lift,—say from 200 to 300 feet, or more if found convenient. The boundary pillars must be larger than ordinary, and of sufficient strength to resist any pressure that might result from the excavation of the coal within the entire area, or 50,000 square yards of the boundary.

Nos. 1 and 2 represent two worked-out boundaries on the upper level; No. 3, one of the boundaries of the lower level. The principal object in laying out the mine into boundaries is twofold: first, to secure all the coal that is possible under any circumstance or by whatever method may be adopted, and to obtain it without injury to the permanent working of the mine, and without waiting for the usual "robbing" of the pillars. Second, to divide the air into separate columns and course it through each boundary and into the return air-course without carrying it through other portions of the mine. These two great objects are accomplished by this simple method without increasing the cost of original investment or the length of time required in opening out a colliery.

It will be observed that No. 4 may be under way at the same time with No. 3; or No. 3 may be exhausted without leaving a pillar, and yet no injury result to No. 4. In fact, the extraction of coal from a boundary of such considerable extent relieves the weight or pressure from the surrounding coal by bringing down the superincumbent strata over its immediate area, and thus letting down a certain amount of pressure, which would otherwise bear on the whole of the mine. In principle and effect it is the same as that followed and recommended by the best mining engineers; that is, the opening of the mine to its limits or main boundaries and extracting the coal in withdrawing or "working back." The only difference is that we lay out an extensive mine in several boundaries instead of one boundary, and effect the same ends with less time and expense.

In a distance of one mile,—which is an ordinary run on each side of the slope in our large collieries,—four boundaries may be laid off, and the first entirely worked out before the last is started, including the pillars of the upper level, which can be of no value whatever after the excavation of the coal below them, except for the purpose of keeping up the water, which may be effectually done, at small expense, by the mode represented in figure 143.

FIG. 143.

WATER-PASSAGE.

This is an adit or drain cut partially in the bottom slate in the gangway of the upper level, and securely timbered or arched before the withdrawal of the upper-level pillars. This drain, being small—about 3×4 feet—and made secure with the refuse timber of the upper-level gangway, will resist all pressure that will be brought upon it on the extraction of the pillars, since the weight will be evenly distributed on the falling of the roof and the entire subsidence of the boundary. But, even if this plan was not adopted, it would be economy to pump the water of the upper level from the lower one, rather than leave so much available and valuable coal to waste.

The plan of ventilation suggested in the plan here proposed is simple and effective.

Each boundary is complete in itself, and supplied with a column of pure air from the main gangway or inlet air-course; these currents sweep the face of each breast, passing in the nearest and most direct way to the return air-course, and thus reaching the upcast shaft, or slope, without mixing their impurities with any other portion of the mine. The number of boundaries at work at the same time would not affect this arrangement: each one receives its column of fresh air, and empties its impurities into the return air-course, which does not pass into any part of the working portions of the mine.

In this respect, the plan may be illustrated by the drainage of a city. Each street and house has its respective channels communicating with the main ones, and the sewerage from each house passes away without injury to its neighbor. But in the systems of ventilation hitherto in use in our anthracite mines, the impurities of one chamber pass into the next throughout the entire mine; and no matter how thorough the ventilation may be, it is more or less defective in this respect.

But the benefits resulting from the plan here proposed are numerous, and none is of less importance than the one mentioned.

First.—The mode of dividing or splitting the air relieves the tension of the column, and the power required to propel it. Instead of dragging the entire column through all the intricacies of the mine, a portion of the weight and friction is relieved at each boundary. We think this so manifest that further proof will not be needed. It is found to work so well in the English mines that "splitting the air" is now a permanent part of their system.

Second.—The danger from gases and the resulting explosions is rendered far less imminent, and accidents are confined to their own locality; the operations of the mine are not materially affected, nor the lives of all the workmen endangered, as by the old system, with the "after-damp."

Third.—The air traverses comparatively short distances, "sweeping" each face with its fresh currents, and depositing its impurities in the common return air-course, without carrying its obnoxious vapors into other working portions of the mine.

The realization of these desirable improvements in our ventilation would not only secure the results specified, but the benefits to follow are of more consequence, in the security to life and health and the saving to capital and property.

But the improvements are not confined to the ventilation: the mode and plans proposed insure economy in the mining of coal, not only in the cost of digging it, but in the great items of dead loss by waste in pillars, &c.

First.—It enables the miner to develop his mine by the earliest and best method known, and, consequently, to realize profit from investments in the shortest time possible consistent with permanence and order.

Second.—It secures labor at less cost, and an increase of work from a given number of hands, from the fact that pure air is supplied in abundance, and that there is less danger to life from explosion and foul air.

Third.—The amount of coal obtained from a given area is increased by nearly one-third, without additional expenses in "dead work," or original expenditure, or the ordinary expenses of the drainage and superintendence of a colliery; thus benefiting the landed proprietors largely, and the operators or miners perhaps not less.

We think the preceding explanation, with the aid of the engraving or plan, will enable most of our practical readers to comprehend the plans proposed, and the improvements therein presented. It will be very difficult for the inexperienced to follow us intelligently, since no subject is more abstruse and intricate than that of mine-ventilation and economic mining. We have met people who had not the first idea of scientific mining, who assumed it to be a simple matter, and, as recently stated in a prominent "guide-book," "only digging a hole in the ground;" but those who know most about it,

and have had most experience with extensive mines and explosive gases, know it to be as difficult a business as men can engage in, and one of the least understood.

BOUNDARY SYSTEM IN FLAT SEAMS.

In this plan we present the boundary system as applied to flat seams and those under 30° of dip, or up to the point at which coal will slide by gravity down the incline of the bottom slate.

As the former is designed for pitching seams where the coal is run in shutes into the cars in the gangway, this is designed for seams where the cars must follow the miner, or where the seams of coal are not steep enough to admit of the use of shutes.

The plan here presented displays the shaft instead of the slope mode, since most

FIG. 144.

PLAN OF THE BOUNDARY SYSTEM, AS APPLIED TO FLAT SEAMS AND THOSE OF LOW ANGLE OF DIP.

horizontal seams exist in comparatively shallow basins, and can be reached by shaft with economy, and drained and worked with more availability by the latter than the former mode. The main gangway, or inlet air-course, leading from the downcast shaft, is *a*, and the return air-course is *b*; *c* is the branch gangway, at right angles with the main one, and between the boundaries, or in the boundary or "barrier" pillar. From *c* the chambers *d*, *d*, are turned at right angles to the branch gangway, and parallel with the main gangway.

The chambers are worked onward to meet those advancing from the opposite side of the boundary, and, when together, the "withdrawing" process is commenced, and all the available coal extracted, leaving the boundary "worked out," and the superincumbent strata on the floor of the seam.

We have only given a view of the first ends of two boundaries,—the first likely to be opened in a mine after sinking the shaft. It will be noticed that a mine can be opened and put in active and productive condition by this method sooner than by any other; and that a large force of miners can be put at work in a shorter time than by any of the old methods.

When the seams are horizontal, the cars can be moved to all parts of the mine by horses; but when the dip is over 10°, gravity inclines must be used in the branch gangways, with a drum and endless chain, or some other mechanical arrangement to take

the cars up the incline. There are several plans in use for this purpose, all of which are applicable, and work rapidly and effectively.

By this mode, a seam of almost any dip can be mined under 40°, and even above that, if desirable; but when the dip is steep enough the former mode is the most effective. When the seam is nearly flat, it may be best to carry the railroad in the middle of the chamber; but when the dip is considerable, it is best on the dip side, against the pillar, and parallel with it, on account of the drainage of water and the handling of the coal. The inequalities of the dip do not affect this mode of mining, and confusion and disorder are almost impossible.

The seam may change from the horizontal to an inclination of 30° in a short distance, without materially affecting the order and plans of the respective boundary workings, since each is distinct and separate from the other. The boundaries may be small or large, as existing circumstances may dictate; but we would recommend 500 yards as about the proper length, parallel with the main gangway. The breadth may be equal or greater than the length along the main avenue, but it should not be much, if any, over a square. If the extent of the property in the same basin is extremely wide, then the pillars between the boundaries should be large and strong, and several boundaries laid out along the branch gangways, and of course the barrier pillars left until the most distant side boundary is exhausted, and the withdrawal commenced at the "far end." This would not often happen in the anthracite region; but in the bituminous, where the seams are nearly horizontal, it might be frequent and difficult to determine in which direction the main avenues should with most propriety be carried. But in any case of the kind the mode proposed is the only one available under all circumstances, and which may be carried to any extent without difficulty or derangement. The coal may be extracted entirely, or with but little loss, in large boundaries, and the superincumbent strata let gently down without danger to the remainder of the mine.

The ventilation by this mode is simple, and each end of every boundary is coursed by a separate and distinct current of fresh air, which sweeps the faces of the breasts and takes the nearest and most direct way to the return air-course. The obnoxious gases are not carried into other portions of the mine. If explosive gases occur, they are swept away at once and hurried off before they can become dangerous; nor are they carried, as in the old system, from lamp to lamp and breast to breast through the entire mine before they find an exit, but enter the return air-course from each set of breasts. This not only insures life, but health and general safety.

Two shafts are better than one to secure perfect ventilation in deep mines; but if one is carefully divided, so as to prevent the air from passing through the casing, a large single shaft will answer the purpose. The engraving with which we illustrate this mode of mining and ventilation displays a large divided shaft. The air passes down the dip side and enters the main gangway *a*, along which it passes to the branch or "barrier" gangway *c*, which part of the air enters, this being the first split. The current continues up the branch gangway to the upper breast. Here it again splits, and turns into the right and left hand boundaries, as indicated by the arrows. It sweeps down the face of the breasts or chambers in each boundary, and enters the return air-course below the lower breast.

The mine may be divided into any number of boundaries desired, either small or large, to suit the character of the dips and undulations of the seam, and this principle of ventilation and mining be retained.

The only objection that could possibly be made to this system is the use of inclined planes; but when we consider that inclines are not required except in a pitching seam, and that such a seam *cannot* be worked without inclines, we cannot see how that objection will hold. In the old modes, every breast becomes an incline in pitching seams, and when the cars are taken after the miner this difficulty exists. The cars may be

drawn by horses; but it is both dangerous and difficult to convey the cars down the inclines from each breast. A single incline between each boundary answers a much better purpose, and can be operated with much more rapidity and safety.

We hope these improved systems have been practically presented, and that the plans will be clearly comprehended, since they require only to be understood properly to be appreciated.

NOTE.—In another part of this work we called attention to the fact that the greatest part of our present production of 10,000,000 tons of anthracite per annum is obtained from a single seam, or the Mammoth; and perhaps we may be safe in stating that 9,000,000 tons per annum are obtained from this source, or, including the loss in waste and pillar, not less than 13,500,000.

This seam is now nearly exhausted above water-level, and it is known to depreciate below. The increase of the coal-trade is about 5 per cent. per annum, and will double itself every 20 years. From this we may easily calculate the exhaustion of our great seam at available depths, and the immense loss we may sustain by practising our present wasteful system of mining, since we may safely estimate 50 per cent. as loss, of which 30 per cent. may be saved by the mode above presented.

CHAPTER XXIII.

SCIENTIFIC AND PRACTICAL MINING.

Science called to the Aid of the Miner—The Engineer of Mines—What is to be accomplished—The Petersburg Mine—Damming the Rapids of Red River—Practical Mining—"Pillar and Stall"—"Board and Wall"—"Long-Wall"—Used at Blossburg—Long-Wall Advancing—Long-Wall Withdrawing or Working Back—Comparison with Board and Wall—The Advantages to be derived from a Perfect System of Mining and Ventilation—Ventilation of Mines—Natural Ventilation—Furnace-Ventilation—Mechanical Ventilation—English Experiments—Waterfalls and Steam-Jets—Mine Gases and Vapors—Light Carburetted Hydrogen—Heavy Carburetted Hydrogen—Naphtha—Petroleum—Mine Gas as a Ventilator—Vapor in Mines—The Safety-Lamp—Stephenson—Davy—Dr. Clanney—Mining Coals—Under-Mining—Blasting—Anthracite Mines—Bituminous Mines—Coal-cutting Machinery.

Scientific mining and practical mining may be said to be almost synonymous terms. But the application of science and the higher intelligences to the practical and experimental part of mining has enabled the miner to penetrate two thousand feet into the bowels of the earth and dig up the mineral wealth hidden by Nature in those deep recesses. There were many difficulties to contend with, which the simple miner could not overcome with his strength or his experience, and which defied his utmost exertions until Watts brought his steam-engine to raise the coal and pump the water from the accumulating depths. But fresh difficulties were constantly arising, which were met and overcome by Davy, Stephenson, Wood, and others, who brought science to their aid.

The engineer of to-day finds no more difficult task to encounter than the proper and judicious planning of deep mines. In the intricate formations of the Pennsylvania anthracite mines the instances of failure are more numerous than those of success.

Something more than simple civil engineering is required of the "engineer of mines." He must be geologist enough to comprehend the lithological structure of the measures he would penetrate, in order to approximate the cost of sinking and see justice done by and to the workmen. The form and undulations of the hidden beds of coal must be unfolded on paper, and the design of the mine-working should be mapped, before the coal is struck or even the shaft begun; since it cannot be properly located until the undulations are approximately marked and the axis of formation determined. To effect the purposes of drainage and ventilation, the depth and character of the coal-basin should be generally known. The principles of mechanics, hydrostatics, and pneumatics are brought into requisition in deep mining; and no one not conversant with those branches of science can successfully engineer and manage the great collieries which the future demands of the coal-trade will require in the deep basins of the anthracite regions.

The want of educated mining engineers—practically educated—is now seriously felt, though not appreciated. Waste surrounds us on all sides. Our coal-beds are so magnificent and our coal-fields so extensive that the waste is not now noticed, though it cannot fail to be felt in the future. If we could see the millions of dollars annually wasted, instead of the tons of coal which are annually buried from view and past recovery, we should then begin to appreciate the want of skill and improvement, and the value of the engineering profession.

Under scientific mining we may include the application of the arts and sciences to all the practical operations of the mine,—the use of the steam-engine in place of the

"pannier-women" who formerly carried the coal to the surface on their backs, and the application of heat or mechanical force to ventilate the mine.

In penetrating the earth 1000 feet, and excavating coal-beds from under immense mountains, whose weight we can scarcely estimate, something more than mere force is necessary. It is not merely the question of obtaining the coal, or of keeping up the mountain, but one of profit and loss, that must be considered. An immense outlay of capital is first required; and, in order to return a reasonable interest on the same, the coal must be obtained as cheaply as it could be dug from open quarries, and the operation must continue for a long period in order to return the investment with the interest. Order and system must be maintained through many miles of under-ground roads and air-courses, notwithstanding the irregularities of the coal-seams and the unforeseen changes of dip, of size, and of coal. One thousand tons of coal per day, or 30,000 cubic feet may be dug from beneath the superincumbent mountains, and yet the hundreds of men must feel safe beneath the mighty mass. This vast quantity of coal must pass through the mine,—sometimes through miles of subterranean passages,—and be hauled to the surface, up the long ascent of a thousand feet, day after day, without intermission. At the same time, nearly 1,000,000 gallons of water must be made to *flow up* from this great depth to find its way to the sea, and over 100,000,000 feet of atmospheric air must be made to circulate through the dim avenues and workings of the extensive mine. All this must be done by scientific and mechanical means. There must be no bungling nor mistakes; for the lives of hundreds of human beings, and perhaps the saving of hundreds of thousands of dollars, depend on the labors of the engineer. If the coal is not dug almost as cheaply as the dirt or earth can be moved from the surface, and in large quantities, the whole thing is a failure: fortune, time, labor, all are spent in vain. If the vast stream of water is not kept steadily flowing up the deep shaft, the mine and all below is flooded; and if the air-currents are suspended only for a short time, the rapidly-accumulating gases endanger both life and property.

Therefore we say the profession of the engineer of mines is the most difficult and responsible in the engineering line. The feat of Col. Pleasants in mining the rebel fort at Petersburg—though a trifle when compared with the design and execution of deep coal-mines—was equal to that of Col. Bailey in damming the rapids of the Red River. The accomplishments, however, necessary to complete the education of an efficient engineer of mines cannot be learned from books or in schools; for, with all the learning that science can impart, or that can be acquired in the most perfect mining colleges of Europe, the engineer is lamentably deficient and incapable, without the experimental and practical part that can only be acquired at the mines.

With the same means, and under the same conditions of natural advantages, we find one mine successful and another a failure, as far as the chief object—*profit*—is concerned. The deeper our mines descend, and the more the coal-trade increases, the more will be felt the want of properly-educated mining engineers. In no mining region within our experience is this want felt and this knowledge required more than in the anthracite fields of Pennsylvania, where the great mass of the coal not only lies deep, but is most intricately and irregularly deposited.

Most of the English coal-fields, like our Western coal-fields, are comparatively simple in their under-ground arrangement, and established rules and plans may generally be adopted: one colliery and all its avenues and chambers may be the duplicate of another, and the same system may be universal throughout a district or a coal-field. But here it is rare indeed to find two collieries alike, or two sets of plans similar: therefore the skill and talent found necessary to conduct successfully the English mines are still more required in the Pennsylvania anthracite mines; and yet we are far behind the English mines in our mining economy. In the manufacture and appli-

cation of mining machinery, however, we are up to the times, and behind no other mining region, though but few of our colliery establishments are planned and erected on the most improved principles. The great defect of our mining economy lies in our miserable and bungling system; and, since the whole depends on this, it is the first subject that should receive our attention.

PRACTICAL MINING.

The first mode of working coal in the early days of mining, or from the first introduction of system in under-ground mines, was by "post and stall," or "pillar and breast," as now practised in this country generally. The plan is to get as much coal as possible, leaving just sufficient pillar to support the superincumbent strata and secure the safety of the workmen.

Where pillars are left, attempts are afterwards made to work a portion of them by "robbing," as it is technically called. But this invariably produces a "creep," or "crush," destroying the remaining coal entirely, or so crushing it as to render it unprofitable and dangerous to work; while the permanent ways are generally injured more or less by the "*crush*," which affects a large extent of the mine.

The English miners for a long period followed the foregoing mode, and left from one-third to one-half the seam wasted or lost in the mine; but, while we are doing this still, they have for the last twenty years been perfecting a new and highly profitable system.

The late Mr. Buddle was the first to introduce the new system in the Newcastle collieries. The plan is to remove *all the coal* and let the roof come down, thus relieving the pressure from the surrounding portions of the mine; but to prevent the crush from affecting other parts, the panel or barrier system was introduced.

The mine is laid out in panels, or boundaries, as described in our last chapter, and *all* the coal within the space removed as rapidly as possible. In England the mode adopted is known as the "board and wall," and consists in driving forward narrow "boards" or breasts to the end of the panel or boundary, leaving large pillars on each side. When the *breasts* are driven to the extent designed,—to the boundary of the mine, or to the barrier dividing one boundary from another,—the miners commence simultaneously to "work back," or withdraw the pillars, on the principle of "long-wall" working. By this plan *all*, or nearly all, the coal in the mine can be extracted; or, instead of leaving one-third as waste and lost, not over *one-tenth* will be left in the mine.

The difference between "board and wall" and "long-wall" is not great, but the modes in which they are applied in different parts of England are very dissimilar.

In Northumberland and Durham, or the Great Northern coal-field of England, the "board and wall" system is generally followed, as above described; but in Lancashire, Staffordshire, and other parts of England, "long-wall" is the mode adopted. While this mode is susceptible of several modifications, it is followed in only two general forms.

The most favored, but perhaps the least used, is to open the mine thoroughly before attempting to work the breasts; that is, the gangways, air-courses, and all the passages to the breasts are finished before the miners commence to work the coal, on the large scale. They then commence "working back," taking out all the coal and leaving the roof to fall behind them, having their air-courses and gangways always open through the solid coal as they advance from the boundaries of the mine towards the shaft. This mode is cheap and effective eventually; but the time required to open the mine, and the great outlay necessary before any return can be made, are effectual bars to its introduction here, particularly when the "board and wall" in the boundary system is equally effective and available.

The second mode of applying *long-wall* is only applicable in small seams with good top slate, or one that produces enough falling material to build permanent ways through the excavated mine. The plan is to work all the coal as the miner advances, and build solid ways with rock or timber behind him through the excavated portions. When these gangways or roads are well built, the permanence of the ways is sufficient for all purposes; but the main avenues or gangways are always protected by strong pillars.

This mode of working we noticed particularly at Blossburg, Tioga county, Pennsylvania, in the Morris seam, which is about 3 feet thick, with a fair roof. Immense props were used—not long, but thick—to protect each side of the passages. Hemlock or spruce trees, from one foot to three feet in thickness, were sawed in lengths a little less than the thickness of the seam, and placed in parallel rows on each side of the wagon or tram roads as the miner progressed; while smaller props were used along the centre of the breast to protect him from the loose slate. These were sometimes removed and used repeatedly, if convenient, and the roof allowed to fall between the roads. The air could not well be crossed, on account of the small size of the seam, and was, therefore, circulated through the mine and returned by a separate air-course not crossed by the tram-ways. The coal was mined remarkably cheap, notwithstanding the smallness of the seam and some mistakes in locating the mine, which prevented the natural drainage of the water. But this plan will not answer for deep and fiery mines, since the gases will in such cases accumulate in the goaves, or excavated portions, and always be a standing menace to the lives of the workmen. The following illustration may convey the idea of this plan of "long-wall" work, though we have given only a small portion of an extensive mine.

LONG-WALL ADVANCING.

It will be noticed by this arrangement that each miner has a "loose end" and a wide

FIG. 146. FIG. 146.

LONG-WALL ADVANCING AND WITHDRAWING.

breast, giving him advantages not to be had in any of the systems now pursued in the anthracite regions. This plan may be used to advantage in most of our small red-ash seams above water-line, where the pitch is not too great to take the cars into the breasts

or chambers, and is the best mode that can be used in the extensive bituminous coal-fields, where timber is plentiful and where the mines may be above water-level, as most of them are and always will be.

In the foregoing figure we represent the breasts as advancing up the pitch in a seam of very moderate dip, or where the dip is not over 5°. When the dip is too steep, self-acting inclines are used, and the breasts or chambers carried at right angles to or parallel with the main gangway on the dip-side, as shown in the figure (146) of "long-wall" in withdrawing or working back.

LONG-WALL WORKING BACK, OR WITHDRAWING.

This plan of long-wall may be used in the panel or boundary system instead of the "board and wall," the only difference being in the board being carried wide and the long way narrow, and that the air is carried across the walls instead of through divided ways. In fact, the boundary system, as set forth in the last chapter, is a compromise between the board and wall and the long-wall. Instead of carrying forward a regular chamber or breast, in which the miner can cut his daily task of coal, the long-wall miners simply carry forward narrow ways, like "headings," at great expense, and from which all the material must be removed. The withdrawing or working-back process is the same, except that the long-wall plan leaves nearly all the coal to be worked on withdrawing, while the former only works back half the coal or that left in the pillars. But either plan is far better than any now in general use among us.

The writer remembers distinctly experiments made in a thin and slaty coal-seam in the Richmond coal-field, with negro miners principally.

Three of the plans laid down in page 416 were tried, but it was found that the seam was too thin and poor to pay. The miners could not cut more than five "bogies" of 10 bushels, or 750 pounds, each, per day. But on changing the plan to long-wall work advancing, and using timber and slate to preserve the tram-ways, the production was increased to ten bogies per day, and all the coal was taken out, instead of one-third, as before.

The advantages of long-wall advancing are numerous in thin, flat seams above water-level; and no plan is better, where timber or rock from the roof can be had to keep up the roads in an available manner. But in deep mines, where the gas is abundant, long-wall must be used on the "withdrawing" or working-back mode, either by going to the boundary of the estate, or by dividing the mine into panels or subordinate boundaries. We would prefer, however, to make use of the "board and wall" plan, or "breast and pillar," as shown in the boundary system; since in that the miner can produce a fair amount of coal advancing, and will have all the advantages of any other plan in withdrawing; while he has room to stow away his refuse,—slate, bone, dirt, &c.,—instead of sending every thing to the surface in advancing, as must be done by this plan in long-wall work.

We do not think it necessary further to illustrate the English board and wall system, since it cannot be comprehensively done in the small wood-cuts which we are using, and we have determined not to make use of large lithographic designs, not only on account of the time and labor necessary to produce them, but because they are inconvenient in book-form. Should it be required, the author will give personal attention to this matter, and furnish full and complete information on the subject.

SYSTEMATIC MINING.

We wish, however, to call particular attention to this important subject, as one of the most interesting questions connected with the mining economy of the anthracite regions,

To the landed proprietors it would save millions of dollars per annum, and to the mining operators perhaps not less; while the miners themselves would be benefited by all that benefited their employers, and would feel more secure in life and limb while engaged in their dangerous occupation. We think the advantages so plain and so numerous that even the prejudiced must admit the desirableness of the improvement. The difficulty, we apprehend, will be that of comprehension: our mining managers are not all engineers, and not generally conversant with plans and paper descriptions; what they know they have acquired by a long experience, and they know, too, that the plans to which they are wedded by a life-long practice are practical in a measure,—that they answer the purpose; while new theories and new plans are to them alike suspicious and untried.

We hope, however, that none will refuse to learn, and that no practical miner will be found to defend our present barbarous, wasteful, and dangerous system, in opposition to the improvements of the deep English collieries, where more coal is produced from a three-feet seam of coal than we can get out of a five- or perhaps a six-feet seam, and at much less cost, even when the rates of labor are compared; where the mines are three times as deep as ours, on an average, and where the gas is constantly pouring forth in a thousand jets, under a tension much greater than any thing we have yet found in any of our deepest mines.

The subject is certainly worthy of consideration and study. But little attention has been given to it. Our miners seem to rest satisfied with the old system, now obsolete in Europe, and have never sought or thought of improvement; and we presume it will be difficult now to change the system, unless those most interested will give the matter their attention.

VENTILATION.

In the economy of mining, particularly in coal where explosive gases are present, the subject of ventilation is no secondary consideration; and the practical miner or engineer is not competent to the management of mines unless he is conversant with the scientific questions necessarily involved in the subject of the ventilation of deep and fiery mines.

It is not our purpose to discuss at present the science of ventilation; this will be involved in the application; but, in order to obtain a clear comprehension of the subject and to present it practically, we must discuss its leading principles; and perhaps the best mode of doing so to the general reader is to make plain and every-day comparisons.

As the wind rushes in storms from the colder to the warmer districts by the increase and decrease in bulk and the ascent and descent of the condensed or rarefied portions in the strata of the air, so the air may be conveyed through any extent of building or subterranean passages. Rarefied air, being lighter than common air, ascends above the common strata, and this creates a commotion, and brings distant currents to replace the ascending column.

When common or natural ventilation is used, the ventilation of a mine is similar, in a limited sense, to that of a house. The air either passes in and through any passage open for its progress, or is drawn in a rapid current by the heat of a fire or a stove. That portion of the air which comes in contact with the fire is rarefied, and of course ascends rapidly through the chimney; and, as it escapes, fresh air takes its place; for "nature abhors a vacuum." In the same manner "furnace-ventilation" is conducted in deep mines.

But in our coal-mines the air is frequently carried through many miles of tortuous subterranean avenues, and too often through irregular channels, where the column is contracted to one-half or two-thirds of its bulk, and of course is to that extent retarded. The friction of air, though insensible when in slow motion, is very great when dragged mile after mile, through rough and jagged avenues, at the rate of 1000 feet per minute.

Through a straight, smooth passage it might be forced along with half the power required to propel it through the ordinary air-courses of the mine.

In most water-level mines, natural ventilation can be made available, entering the air at the lower level and returning it to the atmosphere at a higher point; but even in these, when the avenues are long and narrow, it is extremely difficult to keep up an even ventilation, owing to the constant variation of the temperature of the atmosphere, and the consequent changes in the currents and air-strata. Mechanical means are frequently resorted to even in mines in the mountain-sides, where they are extensive.

The friction of air when carried violently through rough and intricate passages is greater than may readily be imagined. To carry 100,000 cubic feet of air per minute through a single avenue containing 10 square feet of area will require a far greater amount of power than to carry the same amount of air through ten avenues having one-half the area, or 5 square feet to each; and this not only demonstrates the fact of friction, but points at the best mode of ventilating mines. Instead of carrying the air in one unbroken current through the entire mine, it is, therefore, best to split the air wherever convenient, and carry it by separate channels to the respective portions of the mine under operation. But there is another advantage to be gained by this process, in addition to the movement of the column of air. It is evident that all parts of the mine cannot be equally distant from the upcast and downcast shafts: consequently, it cannot be best to carry all the air through the most distant workings, in order to introduce it, with all its foulness, to the near workings. Nothing can be more evident than the economy and propriety of conveying a portion of the current to each part of the mine respectively, thereby not only decreasing the column of air, but giving to each set of workmen their share of pure air. This, however, cannot be done in our present system of mining; but it can be done, nevertheless, with great advantage to all interested, by dividing the mine into boundaries, and carrying a branch current to each, direct from the main column, by the most available way. In order to consider the different modes of ventilation used, we will discuss them under the heads of natural ventilation, furnace-ventilation, steam-ventilation, and mechanical ventilation.

NATURAL VENTILATION.

This is the first and simplest mode, and one which is naturally suggested by the ordinary currents of the air. It is the method always made use of in all new mining districts, except where the seams lie deep beneath the surface. As before stated, the air is carried into the mine at the lowest level, and returned to the atmosphere at a higher level, where the air is more rarefied, and where the atmospheric pressure is the least. Under these circumstances, when the avenues of the mine are regular and proportional, an extensive circulation is maintained, liable to derangements only from sudden changes of the weather and variation of the temperature of the atmosphere.

In deep mines, or most mines carried below water-level, this mode is not available to any great extent. It is very difficult to make any arrangement, under such circumstances, to keep up a current. The levels being equal in many cases, and generally nearly so, the air is in equilibrium, the atmospheric pressure and rarefaction being equal, and there being no tendency to motion. It is true the temperature in most deep mines is higher than the ordinary temperature of the atmosphere, and that the pressure is greater at 500 feet of depth than at the surface; but their effect is equal, and exerted on all portions of the mine alike: consequently, some force must be employed to create a movement and propel a current of air through the mine in a given direction. This is generally done by heat, or the rarefaction of the air in the upcast shaft, which creates a rapid upward movement of the mine-vapor, and, consequently, a downward movement of the atmosphere to fill its place. This method is known as furnace-ventilation.

FURNACE-VENTILATION.

In figure 147, *a* is the upcast slope, or shaft; *b*, the main avenue, or gangway; *c*, the inlet air-course below the gangway; *d*, the return air-course above the gangway; *g*, doors to keep the air in its proper course; and *f*, the furnace. The downcast slope is not lettered, but the arrows indicate the course of the air. The lower passage, *c*, is not indispensable, and may be omitted when the upper or return air-course is carefully preserved. By opening the door *g* in the gangway *b*, the air passes in through that avenue, dispensing with *c* altogether if the shutes are air-tight.

The furnace *f* may be placed to the left of the upcast *a*, perhaps with more pro-

FIG. 147.

FURNACE-VENTILATION.

priety than between the upcast and downcast, on account of the limited room around the bottom of the shaft, and the tendency of the furnace to weaken the pillars. But, wherever placed, the return air must enter the upcast shaft above the point reached by the flame of the furnace, or else, under certain circumstances, the gases brought out of the mine by the returning current of air might be fired. Even with the precaution of a "dummy drift," &c. from the furnace to the upcast, the gas is sometimes fired, by accident, or by the forcing back of the return gases, by the falling of the roof, or from other causes on the flames of the furnace; and this is one of the fatal defects of the furnace as a ventilator.

A large area of grate-surface is necessary, and an immense amount of coal consumed daily, to ventilate a deep mine,—requiring say 100,000 cubic feet of air per day; and the attention demanded is perhaps greater than that where mechanical motors are used. In the furnace system the depth of the shaft is no impediment, so far as experienced, in effecting ventilation. The shaft, if dry, is heated, and retained in that condition by the furnace and the hot air ascending from it; and the consequence is that the air continues in a rarefied state, and escapes upward rapidly, though the "drag" of the column may be considerable.

The following table, from the Transactions of the North of England Institute of

Mining Engineers, will show the amount of coal and the estimated horse-power requisite to obtain a given amount of ventilation, as per experiments conducted at the Hetton, Elemore, and Eppleton collieries, in the Newcastle coal-field.

Collieries.	Downcast Shaft.		Upcast Shaft.						Coal consumed.						Ventilating Column, &c.				
	Name of Pits.	Diameter.	Name of Pits.	Diameter.	Area, in Feet.	Velocity per Second.	Quantity of Cubic Air per Minute.	Water-Gauge.	Number of Furnaces.	Coal consumed per 24 hours.	Number of Boiler-Fires & Steam-Jets.	Coal consumed per 24 hours, in Tons.	Total coal consumed per 24 hours, in Tons.	Columns, Weight, in Tons.	Depth, in Feet.	Temperature. Downcast.	Temperature. Upcast.	Ventilating Column, in Feet.	Horse-Power.
Hetton.........	Minor....	11.5	Blossom....	14.00	132	22	176,000	1.5	4	19.6	3	16	35.6	1115	900	45°	250°	260.1	109.2
Elemore........	George...	12.5	Isabella....	8.75	60	29	104,000	1.0	2	8.5	2	10	18.5	770	780	42°	300°	265.2	66.2
Eppleton.......	Jane......	12.5	Caroline....	11.15	95	29	166,000	2 0	2	8.5	6	28	36.5	1115	1044	50°	200°	257.0	98.6

In the above table it will be noticed that a certain amount of steam is employed. Hetton has 4 furnaces, consuming 19 tons of coal in 24 hours, and 3 steam-boilers, producing steam for jets, and consuming 16 tons of coal in the same length of time; the whole equal to 109 horse-power, employed in mechanical means to produce a ventilation of 176,000 cubic feet per minute.

It will be found, on comparing this with the results of mechanical ventilation as produced by the suction-fan, that it requires double the power to produce the same ventilating column, under the same circumstances, with steam and furnace that it does with the fan. But in this case, though the ventilating power will compare with the best furnace-ventilation in England, the use of the steam-jet in connection with the furnace may rather add to the power required, in a greater proportion than the effect produced. It was decided, by a long series of experiments made in the Newcastle district in England, that furnace-ventilation was the most effective mode then in use; and this decision was considered conclusive until 1863, when questions concerning fan-ventilation, as used in France and Belgium, were discussed among the mining engineers in that district, and the fan was generally conceded to be superior to the furnace so far as the proportion between power and result was concerned. But up to 1864 the fan was only occasionally used in the English mines; and then, with but rare exceptions, the ponderous, costly, and imperfect French system was introduced.

WATERFALLS AND STEAM-JETS.

These modes are now considered obsolete, and are not used, except on rare occasions, when steam can be produced abundantly and cheaply, or when water can be used without repumping, and drained off by some adit level. Waterfalls were much used when natural ventilation was the only other means employed to start a column of air. If a large body of water is suddenly let down a pit, it compels the air to move before it and follow after it; and thus, when the air has become stagnant or in equilibrium by some change in the weather and temperature, the column is started in its proper direction, and may, in shallow shafts, be kept moving by the ordinary means of natural ventilation. It is sometimes used also in starting the furnace-fires, or where weak ventilation is used, because it is much more difficult to put in motion a long column of air than to keep it moving afterwards.

The *steam-jet* is almost valueless in deep shafts if used alone, though it answers very well in shallow ones, and is an aid in deep ones in connection with the furnace. The steam-jet acts like a steel spring. Its action is in its immediate vicinity, and its energy

is soon exhausted. On being released from tension, it suddenly springs upward, and of course moves the air quickly in its vicinity, but its expansion is momentary, or its force confined to a limited area, and does not exert its propelling power to any distance up the shaft. Therefore, if the shaft is deep the steam cools and condenses before reaching the surface, and not only loses its motive force, but actually falls back and retards the column. In a shallow shaft this would not happen, as the steam would reach the surface before condensation took place; and even in deep shafts, where furnaces are used in connection with steam-jets, the action of the latter may be beneficial. The energetic action of the steam on being released from pressure in the steam-boiler moves the air rapidly, while the heat of the furnaces, ascending the shaft, prevents the steam from suddenly condensing. But neither the one nor the other is capable of forcing the air, if much pressure is required, through the contracted avenues of the mine. This can be done only by mechanical means; but in all cases, whatever motive power be used, the more contracted the air-passages may be, the more power is required to produce a given amount of ventilation, or to pass a given number of cubic feet of air per minute through the mine. If it requires a force equal to 50 horse-power to move a column of 100,000 cubic feet of air per minute through the avenues of a mine, it would require 8 times that amount of force, or 400 horse-power, to increase the ventilation to 200,000 cubic feet per minute through the same mine.

If the main avenue of the downcast shaft and the inlet air-courses be equal to 100 feet in area, or 10 feet in diameter, the air would require to travel 1000 feet per minute in order to pass 100,000 cubic feet per minute with the power proposed. But if the area of the air-courses be contracted in any part of the mine to one-half the size proposed, or about 7 feet diameter, the power required to propel the column is increased in proportion to the contraction, but not in the ratio of 8, as before stated, since the contraction of the air-courses impedes the progress of the air in proportion to their length as well as in proportion to their area.

The formula, as found by experiment and practice, is this:—"The pressure per unit of surface, or head of air-column, required for the propulsion of air through a contracted passage, is proportional to the square of the velocity, or to the square of the quantity of air passing in a given time, divided by the square of the area of the air-course.

"The pressure required to propel air through a contracted passage is proportional to the length of the passage, or to the perimeter of the section of the passage, under equal circumstances."

The friction of air through a rough or irregular passage is much greater than through a smooth and uniform one. Unlike water, which flows through a rugged channel of coarse stone-work with as little friction as through glass pipes, it is retarded by friction with every acute angle and every projecting point; and though these interruptions are insignificant as items, they exert a great influence combined; and the "drag" of a column of air several miles in length is much greater through irregular and rough channels than through comparatively smooth and uniform passages.

MECHANICAL VENTILATION.

By mechanical ventilation we mean the use of machinery to compel the uniform movement of a column of air through the avenues and workings of the mine. This is done by various means. That in use was the ordinary fan driven by hand or machinery to propel or *blow* a current of air through certain portions of the mine, or where natural currents could not be maintained. This mode has also been tried for the purpose of extensive ventilation, but did not answer. The difficulty of pushing or forcing a current of air through long, intricate, and rough passages is manifest, and both theory and practice are against it.

Air is an elastic fluid, that increases in tension by the pressure exerted. Air occupying a certain space under the ordinary atmospheric pressure can be reduced to half the space or bulk by double the pressure; and to one-third the space under a treble pressure, and so on: consequently, the density or weight of a given column of air varies directly as the pressure on each unit of surface under which it exists, the temperature remaining unchanged.

The effect, therefore, of forcing air through a long series of intricate passages is to increase its density and friction in proportion to the pressure applied and the length of the column. To a limited extent this may be done by the expenditure of sufficient power, but this may be compared to the attempt to *push a rope* instead of *pulling* it. Whether the ordinary blowing-fan or blowing-cylinder be used, the difficulties are the same: therefore this mode must be condemned. But when the same power is reversed, and the fan or cylinders are made to draw or suck the air instead of pushing it, the effect is reversed, and the natural or atmospheric pressure becomes an active agent instead of a repellant force; instead of increasing the density and consequent friction of the air, it decreases them, and proportionately decreases the amount of power required to produce a given volume or current of air.

We have seen that 109 horse-power produces 175,000 cubic feet of air per minute by the furnace and steam-jets in the Hetton colliery; and this is one mode of drawing a column of air. To propel the same column through the same avenues by any blowing process would require an expenditure of ten times the power, or 1090 horse-power,—which would also so increase the density of the air that it would be extremely difficult to prevent its escape through the doors and divisions of the air-passages to the return air-course before it could arrive at the extremities of the mine.

The expenditure of power, however, is greater by the furnace mode than by the mechanical or suction mode. Lemielle's and Guibal's apparatus for exhausting the impurities of the mine, though clumsy, costly, and ponderous, is more effective than the furnace. These machines produce about 75,000 cubic feet per minute, under an expenditure of 50 horse-power. This, however, is less than the result of the Hetton experiments, which were more favorable than ordinary; and, generally, it is conceded that even Lemielle's ponderous machines are more reliable, safe, and economical than furnaces. There were several of these machines in use in France in 1857–58, and about this time Nasmyth, of England, applied an improved fan as an exhauster in England; but up to 1863–64 they were not in use in the English collieries, with rare exceptions. They had not been introduced by the mining engineers of the North of England at that time, but were under discussion, and generally conceded to be superior to the furnace and more available.

The use of the fan as an exhauster appears to have been first successfully applied in the anthracite region at Locustdale, near Ashland, Pennsylvania, by John Louden Beadle, a mining engineer of much practical experience and ability. It was introduced in 1857–58, after a long series of practical experiments in blowing and exhausting the air, and was adopted as the result of these experiments. This fan, as applied, is the simplest in use and the most effective. With half the expenditure of power and means required in the French suction apparatus, it produces better results.

Mr. Beadle has recently patented his improved fan and system of ventilation; and, from a personal investigation of the plans and their effective operation, we have no hesitation in stating that his system is the most perfect, effective, safe, and economical,—in a word, more available than any other mode of ventilation, and far superior in every respect to the furnace method.

RÉSUMÉ.

The facts we arrive at, after a full consideration of mine-ventilation in all its bearings, which, however, we have but briefly noticed in the foregoing pages, may be summed up in a few words:—

1. The areas of the air-ways should be proportionate in size or diameter to the quantity of air required, since the increase of air in a given area is only accomplished by an eightfold increase of power.

2. The air-ways should not be contracted at any point to a less general diameter than the column requires, moving at a uniform speed, or than the area of the downcast shaft and main inlet avenue; because the increase of density and friction, and, consequently, the power required to propel the column, are in proportion to the contraction of the area.

3. The air-ways are most effective when they are uniform and free from projecting and obtuse angles; because air, which moves in a solid body, impinges or drags on all rough surfaces, and, consequently, the more smooth the surface of the passages the more freely will the currents of air pass through the mine.

4. The longer the column of air, the greater will be the force necessary to move a given column; and the smaller the areas of the passages, the greater the friction and velocity of the air. But the more the air is divided and the greater the areas of the auxiliary passages, the less will be the friction and power required to move a given column, unless increased beyond the area necessary for the full atmospheric expansion: consequently, the shorter the currents, the larger the ways, and the more direct the courses, the more effective will be the ventilation.

5. In order to convey pure air to each breast and to supply each miner with a healthy atmosphere, as well as to shorten the current, decrease the drag of the column, and prevent danger, it is essential that the air be "split" and conveyed by special currents into the respective workings of the mine, and that the returning impurities should pass into the return air-ways without coursing through other workings. To do this effectually, it is necessary that the mine should be laid out in districts or "boundaries," as described in a former chapter.

6. The permanent air-courses should always be parallel with the permanent avenues of the mine, and should never run through the excavated and abandoned parts, except for temporary purposes. "Gas drifts," however, should always be kept open, for the escape into the return air-courses of any gas which might accumulate in the "goaves," as shown by the arrows in several of the illustrations given.

7. Mechanical ventilation, as illustrated by the exhausting-fan, is the most available mode known, and, for present purposes, the most perfect and economical that can be devised.

MINE GASES AND VAPORS.

The principal and most dangerous gas produced in coal-mines, with but rare exception, is carburetted hydrogen, which exists in various forms and in different volumes of carbon and hydrogen, as coal-gas, oil-gas, oil of turpentine, naphtha, petroleum, &c. It consists in this state of about 85 parts carbon and 15 parts hydrogen; but light carburetted hydrogen gas is one part carbon and two parts hydrogen; heavy carburetted hydrogen is one equivalent of each.

Light carburetted hydrogen gas is the most dangerous, difficult, and abundant gas with which the miner is troubled. It issues from nearly all coal-seams, at certain depths from the surface, but generally in greater volumes from the bituminous than from the anthracite coals. It is not confined, however, to the coal-seams, but appears to exist in greater abundance in the rocks below the coal measures, under certain conditions, than

in the coal itself, as is abundantly proved by the immense volumes of this gas which issue from the oil-wells, and by the existence of the oil itself, which is only a heavier compound of those gases, or a maximum of carbon and a minimum of hydrogen.

We think we are safe in saying that even the coal itself is a compound of these gases, with probably certain traces of oxygen. Anthracite contains the smallest amount of hydrogen and the greatest of carbon; the rich bituminous contains more hydrogen and less carbon. Asphaltic coal, mineral pitch, bitumen, coal-oil, petroleum, and naphtha owe their character to the increase of hydrogen and the decrease of carbon; while the carburetted hydrogen gas, which escapes from fissures in our coal-mines and rises from the oil-deposits beneath them, contains still less of carbon and still more of hydrogen.

GAS AS A VENTILATOR.

This gas—light carburetted hydrogen—is about half the density of common or atmospheric air, or of the same lightness and ascensional power as common air rarefied by 500° of heat: consequently, this gas always lies above all other gases or vapors in the mine, and fills all cavities and openings in the roof, or forms a stratum in the higher portions of the mine. If it could escape from thence, there would be little or no difficulty with gas in mines:—in fact, it is possible to make this gas itself a means of ventilation more available and constant in all fiery mines than any furnace can possibly be. The rarefaction of the air by means of furnaces is seldom over 200°, and often not over 100°: consequently, the ascensional tendency by increased lightness is small. But carburetted hydrogen is as light as air at a temperature of 500°, and, consequently, has the same tendency to ascend. If allowed, it would rush through the upcast shaft with great velocity and create a far better current than furnaces could effect. This is evident, since the carburetted hydrogen of the mines, if confined in a balloon, would carry it up with great velocity above the clouds.

If the gas of our mines could be used in this manner with practical effect, it would not only abate a troublesome and dangerous pest to mining operations, but become a valuable and co-operative agent.

In a mine requiring 35,000 cubic feet of air per minute, we may estimate 30,000 feet as necessary to dilute the amount of gas which may be produced,—say 1000 feet per minute, since 30,000 feet of air are necessary to render 1000 cubic feet of gas perfectly innoxious. When diluted with from 7 to 9 volumes of atmosphere, carburetted hydrogen becomes highly explosive and dangerous: consequently, a large excess of pure air is required to make the ventilation safe. "Gas-blowers" frequently break out in portions of the mine, and immense volumes of gas are thus suddenly produced. Often the falling of the roof in the goaves forces the gas into the air-currents, and, were there not a large surplus of pure air, explosions would in such cases be imminent.

We thus find that 30,000 feet of the 35,000 required is necessary to counteract the explosive gases; while only 5000 cubic feet per minute is required to support life and remove the heavy vapors. It is, therefore, evident that a very small amount of ventilating power would be required if the gases were neutralized, and less still if they were made effective in propelling the current instead of furnaces.

This may be a novel idea to many of our readers. It is not, however, new or untried, the system having been in use in several collieries in Staffordshire, England, with great success, and effected by simple and ordinary means.

The plan is to form the return air-courses, in all cases, above the "intake:" if in large seams, they may be made directly over the main avenues and wagon-ways; but if in small seams, then to the "rise," so that the return air may be higher than the entering or intake air. These courses or "gas-drifts" are so located that the gas readily escapes into them from all portions of the mine, and, being exceedingly light,

rushes with great velocity towards the upcast shaft, provided the return air-courses have no depressions and lead invariably to higher levels.

It is also necessary that the *chimney*, or upcast shaft, should be comparatively small, and have no communication with the working portions of the mine. For the ventilation of a mine requiring 35,000 cubic feet per minute, a chimney three feet in diameter is sufficient if the gas is used as described, since the volume is thereby reduced from 35,000 to 5000 cubic feet per minute.

Almost any shaft can be prepared for this mode, by inserting a sheet-iron or cast-iron tube, or by cutting a recess in the side of the shaft and walling it up with brick. Pitching seams are peculiarly adapted to this mode of ventilation; and where gas is plentiful in the anthracite regions there is no difficulty in its use as a proper ventilating medium.

In ordinary furnace-ventilation, where the expansion of the air may be increased from 53° to 105°, 30,000 cubic feet of air entering the mine per minute, at a density of 1000, will leave it at a density of .8774, or .0706 pound to the cubic foot, and with a volume increased to 36,000 cubic feet. The amount of impurities taken up in the mine in the shape of carbonic acid, nitrogen, &c., from the respiration of 300 men and the burning of their lamps, would require less than 1000 cubic feet per minute, since each man produces about one cubic foot of carbonic acid gas per hour, or 300 men about 5 cubic feet per minute, which requires 25 cubic feet of pure air, while the amount to support the combustion of lamps would be still less: therefore, when we say 1000 cubic feet per minute, we allow a superabundance of air for health and all the purposes of the mine. If, however, the mine produces 1000 feet of gas per minute, it requires not less than 20,000 cubic feet to adulterate it above the explosive point, or 30,000 feet to render it entirely safe and innoxious. It is, therefore, evident that the gas of our mines is the great impediment in the way of ventilation, and requires ten times the volume of pure air required for all other purposes. Consequently, if this gas can be made an active instead of a repellant agent, the great difficulty of ventilation is overcome.

The gases most dangerous to miners, next to carburetted hydrogen, are carbonic acid, carbonic oxide, and nitrogen. Carbonic acid is produced by the respiration of men and animals, by the combustion of carbon in lamps or candles, and by other causes constantly operating in deep mines. This gas is fatal to life if mixed with the air to the extent of 12 or 15 per cent. It is a heavy vapor, of a density of 1.548, and can be poured from one bottle to another. It is the lower stratum in all mines, as the carburetted hydrogen is the highest. Lamps will not burn where it exists in an excess of 15 per cent. It is composed of one part carbon and two parts oxygen.

Carbonic oxide is generally produced by the imperfect combustion of carbon. It is a compound of one part carbon and one part oxygen. Nitrogen is the principal element of the atmosphere, and is produced in mines by the extraction of the oxygen, by combustion, or otherwise. These gases are all fatal to life,—either in their proper equivalents, or when mixed with several equivalents of the atmosphere. They constitute the "after-damps" of explosions, and often become more destructive to life than the explosion itself, since the effects of explosions generally destroy all air-ways and main avenues, and not only prevent the escape of the men, but prevent the currents of air from supplying the necessary volumes to render the after-damp innoxious.

THE SAFETY-LAMP.

Many regard the invention of the miner's safety-lamp by Sir Humphry Davy, George Stephenson, and Dr. Clanny—for they are all the productions of about the same period—as improvements in the art and science of mining, and regard those inventors

as benefactors in saving life. But however valuable the safety-lamp has been, and still is, under certain circumstances, and however worthy of honor the distinguished inventors may be, we do not consider that the Davy lamp has conduced to the safety of human life, or the advancement of the science of mining in the proper direction, if we admit the results to be good evidence.

Had this invention been followed by others of a kindred nature, directed against the great prime evil, instead of providing antidotes, it is probable that safety-lamps would long ago have taken the place they were intended to occupy,—to show where the danger existed, and to enable the miner to provide against it. But, instead of this, the "Davy" has made our miners indifferent to the danger; it has given them the means of living and working in the midst of the fiery atmosphere, and they seem to ask no more. They are able by means of the lamp to face the danger and brave it for a time with impunity, but in reality it decreases their security. Had this means not been provided, efforts would have been directed against the evil itself, and the prime cause of the danger would have been removed, instead of being entailed as a constant menace. The consequence has been that the number of deaths by gaseous explosions in mines has been increased by its use.

FIG. 148.

THE SAFETY-LAMP.

The safety-lamp is, nevertheless, a valuable invention or addition to mining science, and, if properly used, might be considered a benefit to the miner. But the practice of working deep and fiery mines entirely with the safety-lamp, of sending hundreds of men to their daily work in an element more explosive than powder, and which the slightest accident or carelessness might ignite, cannot be too strongly condemned. Mines that cannot be worked otherwise ought to remain idle until means be devised to render them safe. This can be effected; and it should be considered a crime to send men to imminent death where it is neglected.

We know it is impossible to keep any deep and extensive mine entirely clear of explosive gas; but there is a vast difference between the jets of gas which are constantly escaping, and which may occasionally lie in the "headings," where currents cannot be carried, and the accumulations of the whole mine.

The danger and the difficulty can be overcome only by removing the prime cause; and the safety-lamp cannot be considered of any real benefit to the miner so long as it diverts attention from the main object. It may be of temporary service to both miner and operator; but, if used as a permanent preventive, it ultimately proves false to both, and brings ruin and death, instead of profit and safety.

The Davy lamp was introduced in 1815, and the "Geordie" of Stephenson and the Clanny lamp of Dr. Clanny were invented and made use of about the same time. The first safety-lamp, however, was made by Dr. Clanny, in 1814; but it was too large and cumbrous for general use, being insulated by water, and fed by complicated contrivances.

The conclusions arrived at by both Davy and Stephenson were the results of practical experiments and scientific deductions. They both discovered that carbonic acid or azote (nitrogen) extinguished flame,—Stephenson by the fact that the burned air from a candle extinguished a jet of burning gas, and Davy by determining that one part of carbonic acid with seven parts of carburetted hydrogen, or one part of azote with six parts of fire-damp, rendered them non-explosive. They also found by experiment that flame would not pass through small tubes or holes. Davy made use of iron-wire gauze of one-fortieth or one-sixtieth of an inch diameter, with 28 wires or 784 apertures to the square inch; while Stephenson at first used punctured tin plates, but afterwards

improved his lamp by using glass and wire gauze. The difference in the Davy lamp and the Stephenson lamp is this:—

In the Davy the air has access through the meshes of the wire gauze on all sides, and when immersed in an inflammable mixture the cylinder is filled with flame, and soon becomes red-hot: the oil ceases to burn, for want of oxygen, but the gas remains ignited while the lamp continues in this condition, and the passage of the flame is prevented only by the radiation of heat from the wires. In this condition it is dangerous.

In the Stephenson lamp the air is admitted through only a few meshes of the wire gauze within a glass cylinder, the latter preventing the entry of any air or gas from the sides: consequently, but a small portion of gas is allowed to enter, and, the interior of the lamp never being filled with flame, no injury can result. In explosive mixtures there not being a sufficiency of oxygen to support combustion, and not a sufficient quantity of gas to support the requisite temperature for its inflammation, the light is extinguished.

The Stephenson lamp is, therefore, a *perfectly safe one*, and not liable to the objections offered against the use of these lamps in the preceding pages, because it will not burn in a dangerous or explosive element.

The Clanny lamp, as improved, produces more light than either the Davy or the Stephenson, but is more dangerous than the latter, and perhaps than the former, because it is protected on the sides by glass only. The principles of insulating the flame and passing the air in and out of the lamp through wire gauze are the same as in the lamps mentioned: in fact, all the improved safety-lamps—and there are a great many of them—contain these principles of the Davy lamp.

Among others, we may mention, in addition to the foregoing, the Museler, a Belgian lamp, much like the Clanny; the Boty, a modification of the same; and the Eloin, with an argand or flat burner, a glass cylinder, and a copper cap, something like those used in our coal-oil lamps, around the flame. It is easily extinguished. In addition to these are the Glover lamp, with a double glass cylinder for protection in case of accident, the Upton & Roberts lamp, which "goes out" in an inflammable mixture, and the Hall and Fife lamps, having a double cap of wire gauze, with glass cylinders.

When lamps on the principle of the Davy, with a covering of wire gauze alone, are used, great precaution should be used in withdrawing them when the internal combustion of the gases takes place, or when the wires of the gauze become red-hot, as an explosion is then imminent.

Lamps having glass cylinders should be carefully used; and the admission of air into the interior of the lamp should be so regulated as to prevent the combustion of the gases within the cylinder; while those with single tops of thin wire gauze are not a sufficient protection against accident.

The Stephenson lamp and those on the same principle are the only true safety-lamps. They will not burn in a dangerous or explosive mixture, and, consequently, cannot be used where men should not be allowed to work. The great objection to the "Geordie" is its small emission of light. The same principle, however, has been improved by Mr. T. Y. Hall, and others, until their lamps emit more light than the Clanny or the Davy, and is so constructed that they will nôt burn in a dangerous mixture, and yet continue to give light until the danger is really imminent. Precautions against accidents are taken; and the miners cannot *light their pipes by sucking the flame through the sides*, as in the Davy and other lamps.

Under such improvements, a real *safety-lamp* may be had, against the use of which there can be no objection, except those before made against the general use of safety-lamps in mining operations as a protection from the danger which ought rather to be removed. This can be done by the ordinary means of ventilation; but, as we have

shown, this dangerous and troublesome element may not only be rendered inoffensive and safe, but may be converted into an active agent in promoting perfect ventilation. The plan is simple, economical, and entirely available. We commend it to the attention of all those who may have fire-damp to contend with; and we may restate the principle in a few words.

Carburetted hydrogen gas, or the fire-damp of our coal-mines, being very light, and having a much greater ascensional power than the air rarefied by our ventilating furnaces, always ascends to the highest points of the mine or working, seeking the means of escape; and if those means were provided the gas would rush out of the mine with great velocity. Therefore, if the return air-courses were so constructed that the gas would invariably ascend to them and in no case have to descend in its exit, it would not only escape as fast as it issues from the fissures of the coal or slates, but would also create a current by the velocity of its movements, and supply a certain and reliable means of ventilation: it would at once reduce the ventilating column from 5 to 1, since the adulteration of the gases beyond the explosive point takes up the great body of air required in fiery mines. It is estimated that 1000 cubic feet of gas requires 30,000 cubic feet of air to render it perfectly safe. Therefore, if the gas was allowed to escape readily, a large amount of this might be dispensed with.

MINING COAL.

As there are numerous modes practised among miners in "getting coal," or *mining it*, as it is technically termed in the anthracite regions, we will describe several of the modes in general use.

In the red-ash seams of the anthracite regions, a stratum or band of soft clay, slate, or imperfect coal is often found, which is known among our miners as "under-mining." This is dug out from under the coal or from between the benches, as the case may be, with small, sharp, and long-handled picks. If the band is of sufficient size, the "holing" is carried in from three to four feet, entirely across the breast; or if the coal immediately over the "mining" is of a nature to be removed without much labor and waste, the same thing is accomplished. But if the stratum of mining is thin and the accompanying coal hard and solid, the holing is not made so deep. In either case the coal is said to be "under-mined" when in this condition, and is then thrown down by powder or iron wedges. Sometimes, when "slippy" or weak, it will fall without further exertion on the part of the miner; and in such cases he is careful to leave small "posts" of mining until the last. These are then pried out with a long pike, or dexterously knocked out with the pick.

This process is known as "kirving," in some parts of England; but there in the bituminous seams the kirving or under-mining is generally made in the coal at the bottom of the seam, which, however, could not be done in anthracite seams, on account of its hardness. Therefore, where "mining" does not exist in a seam, the coal is got by blasting it out with powder; and in small seams the intelligent and experienced miner shows much skill in keeping his breast in working trim, in order to give advantage to the force of the blast by getting his powder in the back of the coal.

Most of our large white-ash seams are mined entirely by the "blasting" process. In the Mammoth bed, which is generally from 20 to 30 feet in thickness, the lower bench is blasted out, much the same as the whole coal is worked in the small, solid seams where under-mining does not exist; or, in other words, the large seam is under-mined by blasting out the bottom bench by a number of small holes. When this is done, the great mass of the top is either ready to fall, or may be easily thrown down by a few well-directed "shots,"—that is, holes drilled into the coal to a greater depth than ordinary, and in the proper places,—and by the use of larger bodies of powder.

Sometimes masses of a hundred tons are thrown down at once in those large seams. The modes of excavating coal in breasts or chambers is much the same in all the anthracite regions. The breasts are generally carried directly up the dip of the seam, and are from 16 to 30 yards wide, with a pillar on either side, and a shute in the middle or on each side, parallel with the pillars. But when the seam is not steep enough for the coal to gravitate or slide down the incline of the shutes, cars are taken into the breasts or chambers, the road occupying the same position as the shutes, except that the roads run obliquely across the dip instead of directly with it. When shutes are used, the miner throws his coal into them, and it is loaded into the cars at the bottom of the shute, which starts from the main gangway; but when the cars are taken into the breasts, the miner throws the coal direct into them, and they go to the surface without further rehandling. There are modifications of these modes; but those specified are generally in use.

Most of the seams in the anthracite regions of Pennsylvania are pitching seams, and dip at varying angles to the centre of their basins. Those which dip at 40° and above can be mined with ease by breast and shute or *runs*, and no other mode can be more available; while those which dip at 10° or less can be mined by breast and cars without much difficulty by the modes generally in use. But the intervening dips are difficult to mine by the ordinary processes, and are generally the most expensive, under equal circumstances, since they are not steep enough for the shute method without planking or the use of sheet iron on which the coal may slide from the miner to the car, and are too steep for the convenient use of the car, which cannot be successfully used on steep grades. In this lies one of the defects of the present system, which cannot be remedied on the principles of mining adopted; and many of our miners are convinced that the English plans cannot be modified to our peculiar dips. But this is a mistake, as we have clearly shown in a preceding chapter.

By adopting the boundary or panel and barrier system, all this difficulty would be overcome, and by the use of inclines the cars could be taken into any breast or chamber, having 40° or less of dip, with ease and economy; and not only would this improvement be effected, but a greater one would be accomplished by the means it offers for the extraction of *all the coal*, and the ability to sweep the workings constantly with pure and fresh air-currents. In flat seams there is more choice of the ways and means of working the coal; but we can advise no better mode than the boundary system, and the advantage of dispensing with inclines, since the cars may be taken by horses into any part of the mine where the seams are of sufficient size. When they are not, the roof may be taken down or the bottom dug up to admit them, or "trams" may be used.

The modes of mining bituminous coals are perhaps more numerous than those employed at the anthracite mines. In the extensive English mines, perfect systems are now adopted, which by extensive practice have proved most economical or available in the district or to the seam and its peculiarities. The board and wall system, with its panels and barriers, of the Northumberland and Durham districts, appears to be the most available under all circumstances; while the "long-wall," as adopted in Lancashire, Staffordshire, and elsewhere, seems to claim equal merits under certain circumstances. But in our bituminous coal-fields neither of these systems is in general use, and are but rarely adopted, though in all cases one or the other, with their various modifications, would add much to the economy of mining coal even when done on a limited scale.

In most of our Western mines, narrow chambers are carried forward, without system, or in conformity with the natural undulations of the seam, which, even when apparently horizontal, generally have an inclination in a given direction, or rolls with gentle undulations. The chambers are frequently very narrow; we have often found them less than twelve feet wide: consequently, the trimming or cutting with the pick

not only doubles the cost of mining the coal, but destroys a great portion of it by breaking it into small coal or dust; while in the long-wall work a much larger amount of coal is obtained in a large merchantable condition, with at least half the work.

We are much surprised at the primitive manner in which those Western mines are worked even in comparatively old districts, though operated by practical English miners, conversant with the improved systems.

We think long-wall *advancing* may be used in most of our limited Western mines above water-level when timber is plentiful, or the roof-rock available for building roadways. But in all cases substantial pillars should be left along the permanent avenues: by this means nearly all the coal in the seam can be obtained at one-half the present cost.

Where the timber is scarce or the roof-rock not available for building protecting walls along the roads, the board and wall system, or a modification of it, as shown on page 432, may be profitably adopted, or the long-wall *withdrawing* may be used with much more economy than the present system of chambers. We think, however, the board and wall, or, as we might call it, the breast and pillar method, when laid out in boundaries, with the pillars left large and withdrawn as soon as the breasts reach the barrier, is the best under all circumstances, either for the moderately pitching anthracite seams or the horizontal and undulating bituminous seams.

We would like to give more definite information on this important and interesting subject, in order to impress upon our miners the utility and benefits of the improvements and to enable them to make use of them; but, except by the engineer, a subject so abstruse cannot be fully comprehended without the aid of plates and diagrams. We are sorry to add that our practical miners, managers, and mining engineers, have given the subject of economical mining little or no attention. They may have sought to mine coal as cheaply as possible by the old and wasteful systems, as they have been forced at times to do from stern necessity. But little or no improvements have been attempted in adapting better and more economical modes to the peculiarities of our coal-fields and seams.

COAL-CUTTING MACHINERY.

We have often heard miners say that it would be impossible to substitute machinery for their labor in cutting coal, and that their trade or occupation could not be interfered with by modern inventions. We cannot understand the desire of the coal-miners to monopolize their laborious and dangerous employment; and we think that any improvement or invention that would lighten their labors must prove a blessing to them instead of an injury. In their case, as in that of all others, any substitution of machinery for manual labor not only lightens their burdens, but adds to their pay and increases the sources of employment. If machines were introduced to do the "holing" or undermining, it would cheapen and increase the production of coal.

It is not probable that machinery will be produced to mine coal in our white-ash *blasting-seams;* but, for the purpose of *mining* or holing—"kirving," as the English miners say—in bituminous coal-seams, they are already successfully at work in several of the English collieries. The plan is very simple, and available in horizontal seams, or in those having a gentle dip; while it may be used in seams of considerable pitch.

There are two modes in use, both as to the means of giving motion and the character of the motion,—compressed air or steam in the first, and the circular motion or thrust in the second. We think compressed air with the thrust motion is the best, since the use of air adds to the ventilation of the mine when below water-level, and particularly in deep and fiery mines, while the thrust motion dispenses with the necessity of complicate machinery.

Air is condensed by a stationary engine placed at the top of the mine, or by an attachment to the rods of the pump, and is confined in appropriate reservoirs in convenient parts of the mine, to which it may be conveyed by pipes; or portable air-cylinders on wheels are filled by the air-pump, and conveyed to the breasts or chambers by the ordinary roads used by the coal-cars. The machine for cutting coal is variously made, but the one which we think most simple and perfect is a plain cylinder, with a thrusting bar or pick attached to the piston. This is securely attached to a frame with wheels and ratchet, and is placed on a temporary track securely fastened down along the face of the coal.

When in place, the working cylinder is connected with the air cylinder or reservoir by means of a flexible tube, and the operator starts it to work by a hand-lever, as he would a steam-engine. The thrusting bar is forced forward against the coal, or in the "mining," until a fair commencement is made, and a full cut of a foot or eighteen inches obtained. The machine is then thrown into self-acting gear, and the thrusting bar or pick works rapidly, while the apparatus is moved slowly forward by a hand ratchet, or is self-acting. Each thrust of the pick takes off a thin slice of the coal the full length of the stroke, and as the machine is moved forward the "holing" is made the full breadth of the breast to the depth of the thrust, say 18 inches, by 3 inches in height. The thrusting bar is then removed and a narrower one made use of, say 2 inches in size, of cutting edge. The machine is then worked backwards, and the second cut is made across the breast until the holing is from two to three feet deep, according to the length of the stroke. If the stroke is only 12 inches, three cuts are made, but if 18 inches, two cuts will do, unless the "holing" is required to be over three feet deep. Three feet is not a limit, however, to the "holing" by this machine, since it can be carried to the depth of five or six feet if necessary, and a cut three feet deep can be made if desired. The piston may work at the rate of 60 strokes per minute, and each cut may take off a slice of coal from one-eighth to one-quarter of an inch in thickness,—say, for example, one-fifth, which, at 60 cuts per minute, would mine 12 inches per minute 18 inches deep: consequently, it would *hole* 30 feet in length by 3 feet deep in an hour, and this would be the minimum duty. It can be made to double that duty by working faster and taking larger slices, depending on the power of the machine. But at the rate mentioned it would undermine 10 breasts, 30 feet wide, to the depth of 3 feet each, in 12 hours, allowing 2 hours for removing and placing the machine 10 times, which would be ample, since the operation is simple; and by having two sets of rails and racks, the breast can always be prepared for the machine in advance.

To accomplish the work done by this machine, 30 men would find enough to do. But, to be within bounds, we will say that ten men, with the aid of the machine, would do more work than thirty men without it, and with this advantage:—the heavy work is done by the machine, and its breathing, instead of vitiating the air in the mine, adds greatly to its amount and purity, particularly in the locality where used.

The illustration given in figure 12, in the early pages of this book, represents the operation of the *iron miner*, but the plan there represented shows the circular or crank motion. The motion of the pick is much the same as that given by the miner. It may be equally effective in operation, but the machine cannot be constructed with as much simplicity as when the direct thrust is used.

There can be little doubt of the utility of these machines for mining purposes in deep and gaseous bituminous mines, and we think their general adoption in all our bituminous mines, where the cars can be taken into the breast, is only a question of time. Our coal-miners need not be jealous of this competitor, since he will not only lighten their labors, but will extend their usefulness and the sources of their employment.

The writer knows something, experimentally, of kirving or under-mining, and can say positively that there is no more tedious, laborious, and tiresome work performed by bone and muscle. We therefore hail the advent of the "Iron Miner" as the precursor of better times for the coal-miners. We may task him without remorse and without stint: he will work in fire-damp or choke-damp without injury to constitution or strength, and will drudge with tireless activity, to the relief of the hard-working and poorly-paid "kirvers."

CHAPTER XXIV.

THE PRACTICAL DEVELOPMENT OF MINES.

Drifts—Tunnels, &c.—Drainage by Tunnels or Adits—Slopes *versus* Shafts—Hardness of the respective Strata in the Anthracite Measures—Location of Mines—Table of Distances, Vertical and Horizontal, through the Anthracite Coal Measures—Mining Machinery—Lifting-Power—Size and Style of Engines—Boiler-Capacity—Single and Double Connected Engines for Hoisting Coal—Drums and Ropes—Box Cages—Pneumatic Lifts—Safety-Cages, Travelling-Rods, &c.—Pumping-Machinery—Cornish Pumping-Machinery—Rules and Tables—Horse-Power—Steam—Air—Water—Diameters—Weights—Ropes—Chains—Outside Fixtures—Mining Economy—Improvements—Waste at the Mines.

In opening and practically developing mines of coal, much depends on the natural condition in which the coal exists. In some localities the coal is entirely in the mountains and above water-level, as shown to be generally the case on the Great Kanawha River in West Virginia and many other places in our Western bituminous coal-fields; while in others part of the coal is above and part below water-level, as in the anthracite coal-fields of Pennsylvania, the vicinity of Pittsburg, and many other places; and in other instances the coal is almost entirely below water-level, as in the Richmond coal-field, the English Newcastle mines, &c. &c.

Drifts, levels, or gangways, are generally employed above water-level when the seam can be approached without tunnelling through the overlying or underlying rock. When this is necessary, rock tunnels are used, as shown in figure 139, where tunnels are made use of to reach the seams, below water-level, though both underlying and overlying; but above water-level tunnels are seldom required to penetrate the underlying strata in order to reach the seams. This condition sometimes happens, however, where the seams have a low angle of dip into a mountain-side, and cannot be followed by drift on the seam on account of water. In this case a tunnel is started below the seam and run in under it until the coal is reached.

Tunnels are galleries or subterraneous passages cut in the rock; and "drifts," as technically called, are avenues of the same description cut through, or in, the coal. We will not, however, dwell on these, as they have been partially described in the preceding pages. They are the simplest modes of mining, and should always be made use of where they can be made available. As a means of draining mines they are most effective, and may be made use of to a much greater extent than they are. For instance, a slope may be 100 yards deep and productive of a large amount of water, which requires the expenditure of $20,000 in machinery and pumps for its drainage, besides a constant expense of from 20 to 30 dollars per day in labor, oil, coal, &c., to keep in operation while the "lift" may last,—say for five years,—or a total expense of $62,000. This drainage may be effected by tunnel, in many instances, by one of from 250 to 500 yards in length, which at $40 per yard would only cost from $10,000 to $20,000. In many cases where much water exists and powerful and costly machinery is made use of to drain the mines, it would be better to drive a mile of tunnel, if available, than to erect machinery and entail the expense of constant drainage. We may instance the Wiconisco mines at Bear Ridge, the Room Run mines at Nesquehoning, and some of the Wilkesbarre mines; since one tunnel would drain several operations.

The cost of tunnelling in the anthracite regions varies from $25 to $75 per lineal yard, when miners receive about $1.50 per day. The cost depends on the measures through which the tunnel may be driven, as shown by the table on another page. For instance,

the measures between the Seven-Feet and the Mammoth are soft slate, and can be worked at a low price; the same in the vicinity of the Primrose and the Big Tracy. But in the vicinity of the Lewis, the Holmes, and the Buck Mountain the rocks are very hard, and the cost is materially increased.

SLOPES.

In the anthracite regions, where the seams dip at a high angle, slopes dug in the seam and following its dip are generally made use of, in the manner set forth in figure 139, and as represented in several illustrations on other pages. This mode is the most available one that can be adopted under such circumstances, in our deep basins. The cost of labor in sinking slopes is less than that of tunnelling, or perhaps about equal, when timber and the cost of drainage, &c. are included, and is only one-fourth the cost of shafting as an average.

The cost of labor in sinking slopes ranges from 25 to 50 dollars per yard, and that of shafting from 100 to 300 dollars per yard. If we take the minimum, the cost is four times greater; but if the maximum, the cost is six times greater. A slope 100 yards deep may cost $5000 for labor, but a shaft of the same depth would cost $30,000 in the same proportion.

At a dip of 45° it would require a slope 1500 feet long to reach a basin 1000 feet deep, and the difference in cost would be $75,000 in favor of the slope; and as 100 yards of a lift is as much as can be economically worked in seams of this pitch, the coal could be mined by the sloping process with much more availability than in the shaft. The shaft must go down to the basin, and the coal, when mined, is with much difficulty brought down the long range of dip or "breasting," by inclines or otherwise. All the coal and all the water must therefore be lifted a thousand feet through the shaft, when one-fifth of it would only be lifted that distance vertically in the slope, though the increase of length would be nearly one-third; but this does not increase the cost in the same proportion, since the same power in machinery will lift water 1000 feet high through 1500 feet of pipe at 45° as easily as 1000 feet high through 1000 feet of vertical column, while less powerful machinery is required to lift the coal 1000 feet high at an angle of 45°, and a distance of 1500 feet, than 1000 feet by perpendicular lift; on the same principle that it is easier to draw a load on a railroad of 20 feet grade to the mile than on one of 100 feet grade. In a slope of 60° or less, the car alone or a small additional weight for following truck is lifted with the coal on a railroad-track, but in the shaft not only the car and coal must be lifted, but the additional weight of a heavy "cage," which is frequently one-third of the load.

But, in addition to those advantages, while only one-fifth the coal is to be lifted the full perpendicular height of 1000 feet in the case under consideration, the other four-fifths are respectively lifted only 800, 600, 400, and 200 feet: and this, of course, means the water as well as the coal. To be more explicit to the inexperienced, we may state that the first *lift* of a slope should not be sunk over 300 feet on a seam pitching enough to "run," or over 35°. The coal is then worked out to that depth from one end to the other of the property on the "strike" of the seams. When this is done, the slope is sunk another lift of 300 feet, and the same process repeated, and so on successively until the basin is reached. It is thus evident that the coal is not only mined with more economy, since 100 yards is of sufficient length for any breast in which the coal runs from the miner to the cars in the gangway, but that only a small portion of both coal and water is required to be raised the full distance specified of 1000 feet, in the case of a shaft.

The same arguments hold good in nearly all pitching seams from 30° to the perpendicular. If shafts are used of less depth than 1000 feet, or the depth of the basin, only

that portion of the coal which is above the point of intersection with the seam can be mined from the level of the pit; and, if a greater depth is required, the shaft must either go down through and below the seam, and the coal be again cut by a right-angled tunnel, or a slope must be made use of from the bottom of the shaft: therefore, under such circumstances, a slope on the underlay of the seam is always more available than a shaft.

SHAFTS.

When the seams have a limited dip, say 25° or less, and where cars can be used in the breasts, shafts are more available than slopes, since the length of the slope is proportionately increased, while the depth of the shaft is decreased; and the objections to the length of breasts do not hold good under these conditions, because in seams of 25° or less the cars can go into the breasts, and the lift is not of so much importance. Still, it is a question of some doubt at what angle of dip slopes become more expensive than shafts; and some practical men, of much experience, are of the opinion that slopes on the underlay of the seam are the most available so long as the dip is sufficient to allow the car to drag the chain or rope down the incline by its gravity. For the purpose of drawing coal, the incline principle is to be preferred whenever a mine can be slanted on the dip of a seam, since more coal can be raised on an incline than through a shaft, even if the distance be ten times greater. An engine of 100 horse-power will draw up a train of cars with 20 tons of coal over an incline of 10° with greater ease than 2 tons of coal up a shaft. But generally we would prefer shafts to slopes when the dip is under 20°, except for the first two lifts near the surface. There are, however, instances of frequent occurrence where shafts are the only available means of reaching the coal, even when the seams have high angles of dips. This may happen when the boundary lines of estates cannot be located on the outcrops of the beds, or when the outcrops of the seams are very high on the mountain-sides, and positions for machinery cannot be obtained. In the first case, shafting must be resorted to, and in the latter, tunnels may be used to cut the seams above water-level, and slopes below that point, though sometimes slopes are used from the end of the tunnels on the dip of the seam, in the same manner as when started from the surface; and this plan is available, and may be advantageously made use of, under certain conditions.

In other instances, the seams undulate in such a manner as to form basins whose outcrops do not come near the surface, and on which slopes cannot be used; for instance, the Mammoth bed undulates in four or five successive basins between the Mine Hill and the Sharp Mountain, in the Pottsville district, yet the outcrops come to the surface only in one or two of these basins near the Mine Hill: consequently, this seam can be reached only by shafting; and the same may be said of many of the overlying and of all the underlying seams.

Sometimes the anticlinals of these concealed formations come comparatively near the surface. When these anticlinals can be correctly located, a shaft on their axis may be made available at a limited distance and cost, and from the point of intersection slopes may be put down the respective dips to the basins, on each side of the anticlinal. By this arrangement the coal of two basins may be obtained through one shaft, not only from a single seam, but from all the seams whose anticlinal axis is penetrated by the shaft. To make such a shaft fully available, it ought to be very large, in order to admit of several hoisting apartments, and of a separate compartment for the pumping apparatus and upcast shaft, or air-course, since a steady current cannot be maintained in a shaft where the cars are constantly passing up and down. It would be also desirable, in case a large amount of coal is required, to have separate hoisting-ways from each dip of the Mammoth. The lower seams could be cut by tunnel, and the coal raised through the

same ways, while the upper seams would be more available after the lower ones are exhausted.

The cost of sinking shafts varies considerably in the measures of the anthracite regions. Where the strata are composed of slate, shale, and soft sandstones, the cost of sinking is less than where they are composed of harder material,—sandstones, rocky conglomerates, &c. In the vicinity of the Tracys, or between the Little Tracy and the Lewis, or Gate, we find some very massive and flinty rocks of great hardness. We also find a few hard strata between the Diamond and the Big Tracy, and between the Orchard and the Diamond; while a very massive and compact coarse sandstone exists between the Holmes F and the Seven-Feet, above the Mammoth. Below the Mammoth the measures are generally hard, with the exception of a few thin strata of slate; but above the Gate bed a rock of peculiar hardness exists, which may be equally expensive to cut.

The cost of sinking is in proportion to the size of the shaft and the hardness of the rock: much more, however, depends on the latter than on the former. In the softer strata, a shaft 10 by 20 may be sunk for 200 dollars per linear yard, when the wages of miners are about $1.50 per day; but in the harder metals the cost of sinking the same-sized shaft will be over 300 dollars per yard. As an estimate, however, we do not think a shaft could be sunk 1000 feet through the anthracite measures in the centre of any basin for less than an average cost of 300 dollars per yard, independent of the cost of pumping and hoisting and of the material used. It depends, also, irrespective of hardness, on the dip of the measures where the shaft may be sunk. As a general rule, it is easier to sink in the centre of a basin, where the strata are comparatively flat, than on the dips of the measures, where the strata have a high inclination, since it is more difficult to advance against the ends of the strata than to go through or across them.

Sinking is more costly in the measures of the anthracite coal-fields of Pennsylvania than in the bituminous coal-fields of the West or in the English bituminous coal-fields, since the metals in the former are much harder than in the latter. It seems to be a characteristic of the anthracites generally; and we have no doubt that the greater heat which accomplished the change from anthracite to bituminous converted the rocks from a ferruginous or soft sandstone to a crystalline or more silicious and flinty nature, since the stratified crystalline and sub-crystalline rocks are harder than the upper sedimentary.

But, while the cost of labor in sinking is less, the actual cost of putting down a shaft in the deep bituminous basins is generally much greater than it is in the anthracite basins, owing to the open nature of the measures, and the immense quantity of water which they contain. In many cases the cost of sinking 1000 feet in the Newcastle coal-field has been over 1000 dollars per yard. We do not think the cost of sinking in any of our anthracite basins can exceed $500 per yard as the full expenditure, if proper precautions are taken.

LOCATION OF MINES.

In some cases there is not much choice of location; but generally there is some point more available than another in reference to the permanency of the mine and the economy of mining the coal. In this country regard is too often paid to outside or surface advantages, at the expense of general availability. But there are advantages of importance to be taken into consideration in the location of the outside establishment as well as the inside workings,—in regard to the cost of erecting the buildings, the location of machinery, the movements of the coal from point to point, disposition of roads for the cars, room for refuse, &c. &c. But in regard to the internal working there is no remedy. When a hole is sunk in the ground, and the shaft established, there is no

removing it, though it may be greatly in error, or in the wrong place. When the mine is established on the dip of a basin, the point of its location is not of so much importance; but, even in this case, the division of the boundary, the increase and decrease of dips, and the position of "minor rolls," or subordinate basins, have much influence on the availability of the works. But when a basin or a saddle—that is, the synclinal or anticlinal axis—is to be reached, it is important that the location of the shaft be correct, or in such a position as to command the coal without the use of dip-workings. We may cite many cases where shafts have been located wrong by a few hundred feet only, yet enough out of the way to occasion great expense and much inconvenience and cost in mining operations.

In sinking to the bottom of a basin it is not always possible to reach its greatest longitudinal depth, as some basins are of great length; but it is almost always possible to reach its transverse depth; and this is the most important, because the dip is always greater in this direction than in the former, as may be observed by contrasting the sections in figure 22.

The proper location of shafts, therefore, will be a question of some importance in the future, when our deep basins must be developed; and, since they are generally irregular, having their axis rather to one side of than in a line with the apparent surface-axis, we have given an illustration of the proper positions, and pointed out the errors that might occur if the conditions represented are not observed.

In figure 149, we give the general form of our anthracite basins in the Pottsville district; and, while the same form does not hold good in the other districts, the principle is general, though the formations are less abrupt in a northern and western direction. It will be observed that the bottom of the basin or the centre of the synclinal

FIG. 149.

LOCATION OF SHAFTS.

axis lies nearest to the steep side, or where the dip is greatest. This is a natural consequence, and is invariable. The centre of the basin appears to be at the dotted line $a' a'$, judging from surface indications, and an inexperienced person would naturally commence to sink at this point; and the error would be serious, since half the coal in the basin would lie to the dip side, and could only be obtained by dip workings or the extension of the shaft below the coals, which are then reached from the bottom of the shaft by tunnels. The process would be tedious, expensive, and inconvenient, as a tunnel would be required for each seam.

By a little observation and calculation it may be conclusively determined that a is the proper place for the shaft, and that, by sinking here, several important advantages will be secured: the cost of sinking through and in the vicinity of a coal-bed is one-half less than that of sinking through the measures, as at $a' a'$; the shaft can be sunk in half the time, and the saving for a shaft 1000 feet deep would not be less than $50,000, while the

coals of the basin would be reached at a point where they would all be commanded without dip workings, &c.

It will be observed that the natural consequence of the formation represented is to throw the apparent centre of the basin far to the right of its real position, while the actual centre is as naturally thrown to the left. The same result happens to the anticlinal or saddle. Each seam has its axis progressively thrown to the left, and a shaft at the dotted line *b*, would strike the axis of the upper seam, but would miss the axis or saddle of the lower one considerably, and be seriously in error if it were calculated to work both basins by slopes from the bottom of the shaft. But a shaft at *b*, *b*, to the axis of the lower seam, would not only be in proper position to command the coal of that seam, but all the seams in both basins, since the slope in passing the roll *c*, *c* may be continued in its proper direction on the dotted line *f*, *f*. But the continuation of the slope through the slates would be best accomplished after the extraction of the coal from the point *c′* to the bottom of the shaft, or all the coal of the roll and above it, since this would form the second "lift" according to our scale, supposing the shaft *a* to be 1000 feet deep. We have given the shaft *c*, *c*, and the dotted line *c′*, to show how a shaft may be sunk in error even on the dips of a basin; but the location of a shaft at this point depends on future operations. If it was designed to work the dip-coal by slope from the bottom of the shaft, then the location at *c′* would not be wrong, since the roll and the upper coals could be reached by tunnel; whereas, if located at *c*, *c*, slopes would be required on the principle of *f*, *f*, in order to reach the dip coal, which would be more expensive than tunnels from *c′* to reach the upper coals. But, in case it is not intended to work the dip coals by slope from the bottom of the shaft, it is better to sink the shaft at *c*, *c*.

Surface indications, or the strata near the surface, are always a good guide in regular basins; but, in irregular formations, experience and geological knowledge are required to locate mining operations properly. In the following table will be found some interesting and valuable information. The data were prepared by Mr. John Holmes, a practical miner of St. Clair, and the calculations made by General H. Pleasants, of Pottsville.

This table gives the distances of both shaft and tunnel from one seam to the other under different degrees of dip, and the relative cost of sloping, tunnelling, and shafting, from one seam to the other, through the intervening measures. It also gives the vertical or right-angle distances from one seam to the other; and we have added our nomenclature, or alphabetical letters, to the common names of the seams as accepted in the Pottsville district.

We think the distances given in this table are the minimum distances for the Pottsville district, and will not conform to the distances general in the anthracite regions. We find the distance at Scranton from A to J to be only 455 feet vertical; at Pottsville the distance is over 1000 feet; while at Locustdale, near Ashland, in the Mahanoy region, it is considerably greater, as shown in figure 59. But by taking the vertical or right-angle distances, as given in the various vertical sections of the several regions and their relative dips, an approximate tunnel and shaft distance can be obtained by the relative computation given in the table.

We find the distance from M to L, or from the Lewis to the Little Tracy, to be 150 feet at right angles to the dip, and the horizontal or tunnel distance, at 15° of dip, to be 579.5 feet, while the shaft distance is only 155.3 feet. As the dip increases, the tunnel distance decreases, and the shaft distance increases: therefore, at 75° of dip, the tunnel or horizontal distance is only 155.3 feet, and the shaft or vertical distance 579.5 feet, which is the reverse of 15°, because the 75° from the vertical is the same in reverse as 15° from the horizontal. This rock is very hard, and we find the cost to be $60 per lineal yard for tunnels, $250 for shafts, and $30 for slopes, when labor is at $1.50 per

TABLE OF SHAFT AND TUNNEL DISTANCES FROM ONE SEAM TO THE OTHER, UNDER DIFFERENT DEGREES OF DIP.

Names of Workable Coal-Beds.		Average Thickness of Coal.	Thickness of Rock at Right Angles to Dip.	Dip, 15 degrees.		Dip, 20 degrees.		Dip, 25 degrees.		Dip, 30 degrees.		Dip, 35 degrees		Dip, 40 degrees.		Dip, 45 degrees.	
				Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Sandrock,	N.	8	180	502.3	134.6	380.0	138.8	307.6	143.4	260.0	150.1	226.7	157.8	202.2	169.7	183.8	183.8
Lewis,	M.	9	150	579.5	155.3	438.6	159.7	354.9	165.5	300.0	173.2	261.5	183.2	233.4	195.8	212.1	212.1
Little Tracy,	L.	4	72	278.2	74.5	210.5	76.6	170.4	79.5	144.0	83.1	125.5	87.9	112.0	94.0	101.8	101.8
Big Tracy,	K.	9	132	510.0	136.7	386.0	140.5	312.3	145.6	264.0	152.5	230.1	161.2	205.4	172.4	186.7	186.7
Clinton.		2	60	231.8	62.1	175.4	63.9	142.0	66.2	120.0	69.3	104.6	73.2	93.3	78.3	84.9	84.9
Diamond,	J.	7	270	1043.0	279.5	789.4	287.3	638.9	297.9	540.0	311.8	470.7	329.6	420.0	352.5	381.8	381.8
Orchard,	H.	6	150	579.5	155.3	438.6	159.7	354.9	165.5	300.0	173.2	261.5	183.2	233.4	195.8	212.1	212.1
Primrose,	G.	10	70	270.5	72.5	204.7	74.5	165.6	77.2	140.0	80.8	122.0	85.5	108.9	91.4	99.0	99.0
Holmes,	F.	4	200	772.7	207.1	584.8	212.8	473.2	220.7	400.0	231.0	348.7	244.2	311.1	261.1	282.9	282.9
Seven-Feet,	E.	7	20	77.3	20.7	58.5	21.3	47.3	22.1	40.0	23.1	34.9	24.4	31.1	26.1	28.3	28.3
Mammoth,	E.	26	90	347.7	93.2	263.1	95.8	213.0	99.3	180.0	103.9	156.9	159.8	140.0	117.5	127.3	127.3
Skidmore,	D.	8	225	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Buck Mountain,	B.	10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

Names of Workable Coal-Beds.		Dip, 50 degrees.		Dip, 55 degrees.		Dip, 60 degrees.		Dip, 65 degrees.		Dip, 70 degrees.		Dip, 75 degrees.		Average Cost of Tunnelling, per Lineal Yard.	Average Cost of Shafting, per Lineal Yard.	Average Cost of Sloping per Lineal Yard.
		Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.	Horizontal or Tunnel Distance.	Perpendicular or Shaft Distance.			
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Dollars.*	*Dollars.*	*Dollars.*
Sandrock,	N	169.7	202.2	158.7	226.7	150.1	260.0	143.4	307.6	138.3	380.0	134.6	502.3	60	250	30
Lewis,	M	195.8	233.4	183.2	261.5	173.2	300.0	165.5	354.9	159.7	438.6	155.3	579.5	75	300	30
Little Tracy,	L	94.0	112.0	87.9	125.5	83.1	144.0	79.5	170.4	76.6	210.5	74.5	278.2	35	175	26
Big Tracy,	K	172.4	205.4	161.2	230.1	152.5	264.0	145.6	312.3	140.5	386.0	136.7	510.0	30	200	25
Clinton		78.3	93.3	73.2	104.6	69.3	120.0	66.2	142.0	63.9	175.4	62.1	231.8	25	200	30
Diamond,	J	352.5	420.0	329.6	470.7	311.8	540.0	297.9	638.9	287.3	789.4	279.5	1043.0	35	220	25
Orchard,	H	195.8	233.4	183.2	261.5	173.2	300.0	165.5	354.9	159.7	438.6	155.3	579.5	40	230	25
Primrose,	G	91.4	108.9	85.5	122.0	80.8	140.0	77.2	165.6	74.5	204.7	72.5	270.5	30	250	35
Holmes,	F	261.1	311.1	244.2	348.7	231.0	400.0	220.7	473.2	212.8	584.8	207.1	772.7	60	275	30
Seven-Feet,	E	26.1	31.1	24.4	34.9	23.1	40.0	22.1	47.3	21.3	58.5	20.7	77.3	25	100	40
Mammoth,	E	117.5	140.0	109.8	156.9	103.9	180.0	99.3	213.0	95.8	263.1	93.2	347.7	70	300	50
Skidmore,	D	......	......	......	......	......	......	......	......	......	......	......	......	70	300	40
Buck Mountain,	B	......	......	......	......	......	......	......	......	......	......	......	......	...	.....	...

day for miners; the shaft being about 10 × 20 feet in diameter, and the tunnel 7 × 10 feet. The slopes vary with the size of the seams, and are made in proportion: therefore the cost of sinking on a small seam is from $25 to $30 per yard, while on the Mammoth it is $50 per yard. These figures include only labor; the outlays for material, timber, machinery, cars, and hoisting and pumping, are additional.

In order to find the depth of a basin by this table, it will be necessary first to get the average dip of some well-known seam; find the distance from that to the basin of the seam required, and then the distance from the same point to the centre of the basin as nearly as can be approximated by surface indications, taking care to allow for any difference in dip that may exist between the opposite sides of the basin, as described in figure 149.

We wish, for instance, to find the depth of the Mammoth at a certain point where this seam does not outcrop; but we find the outcrop of the Primrose, which we know is from 290 to 300 feet above the Mammoth. We wish to start a shaft on the north side of the basin, 150 feet south of the outcrop of the Primrose, which we find to be near the outcrop of the Orchard. The average dip is 15°, and we find the vertical distance to be about 455 feet, which is verified by the St. Clair shaft, commenced and sunk under such circumstances. To find the basin of the Mammoth under a dip of 25°, we find the outcrop of one of the upper seams—say the Big Tracy—and measure the distance to the centre of its basin. We find the distance to be 638.9 feet, the perpendicular 270, or the distance at right angles through the measures, since the dip is 0° in the centre of the basin. If the dip has been preserved at 25° the whole distance of 638.9 feet, the perpendicular will be 297.9 feet. We find, therefore, the depth to K, or the Big Tracy, to be 270 feet in the centre of the basin, where the distance from the outcrop of the same is 638.9 feet, and the dip 25° on an average. This being demonstrated, we find by the table that the distance from K to E, or from the Big Tracy to the Mammoth, is 902 feet: consequently, the whole distance is 1172 feet. This we consider a minimum. The probability is that the distance would be rather over this calculation.

The approximate distances are given in the vertical sections accompanying our descriptions of the respective coal regions, and the approximate depth may be obtained in the same manner by finding the basin of some upper seam and then adding the distance as given from the seam found and known to the seam wanted, in the centre of any basin. But if the shaft is located on the dip, the average angle of the dip must be demonstrated, and the perpendicular depth found from the accompanying table, allowing for the increased or decreased thickness of the measures, as found on comparing the vertical column of the region with the distances in the table.

MINING MACHINERY.

However important the location and development of our mines, and necessary as may be the knowledge and experience to accomplish their development, these requisites are, perhaps, not more important or necessary than the mechanical skill and judgment required in designing or selecting the most available machinery for the place or the purpose. This is evident: we have seen it demonstrated on so many occasions, and in so many places, that we often feel surprised and pained to witness so great a lack of tact where so much mechanical skill exists. The want is not in the ability to manufacture, but to apply the necessary mechanical power. We do not wish to make invidious mention, but within our experience we could point out a hundred cases where the most serious consequences, in increased expenditure and waste of power, have resulted from misapplication and miscalculation.

In mining machinery, two important considerations require the first attention, viz.:

simplicity and strength. In colliery engines, the question is not so much economy in the use of fuel, as availability in mining operations; power, durability, and general simplicity of style are the most essential requisites; and, whether designed for hoisting or pumping, the more compact and concentrated their efforts, the more serviceable and permanent will be their duty. But the style of the machinery is also an important consideration. Heavy engines are now generally required, since our mines are increasing in depth as our colliery establishments increase in proportion; and larger quantities of coal are required as their product in order to compensate for the increase of the original outlay and the general daily expense.

If ten tons of coal, car, cage, and rope are to be lifted 1000 feet per minute, we can form some idea of the size and power of the machinery, taking Watt's calculation of the duty of a horse-power for our guide. At 33,000 pounds lifted one foot high per minute, as the law of a horse-power, it would require 600 horse-power to lift 10 tons 1000 feet per minute; or, by gearing, to lift the same in two minutes, 300 horse-power would be the calculation. But in our mines we always balance the cage and the car: we have, therefore, on starting, 3 tons less, and 200 horse-power will do the work designed,—that is, lift ten tons 500 feet per minute,—providing the balancing power is equal to one-third of the load.

With machinery of such power it is necessary to calculate the area of the piston-head in proportion to the load to be lifted, since the speed of the piston and speed of the load cannot be varied to the extent they may be in smaller engines. If the drum on which the rope winds is 12 feet in diameter, the pinion on the crank-shaft be 4 feet, and the stroke 5 feet, or the crank 2½ feet, the piston must move at the rate of 413⅓ feet per minute to move the load at the rate of 500 feet per minute, and the number of revolutions must be 41⅓ per minute,—which is faster than an engine of 200 horse-power ought to move. But by arranging the engines as two 100 horse-power connected link-motion engines, their speed might be increased, and the load moved at the rate of 500 feet per minute, with great facility.

Twenty revolutions per minute would be a fast speed for a 200 horse-power engine with a stroke of 6 feet: therefore, to move a load at the rate of 500 feet per minute, the pinion would be 8½ feet diameter. But by the use of two connected 100 horse-power engines the speed may readily be increased to 40 revolutions per minute, and the pinion reduced to 4¼ feet, while the stroke may be 5 feet or less. This arrangement increases the leverage or power of the engines one-half, and has the advantage of keeping one of the engines continually on the "*live centre;*" but the amount of steam used is thereby considerably increased. This, however, would be a necessity, under the circumstances of lifting a load of 7 tons, or 14,000 pounds, 500 feet per minute, since a 200 horse-power engine would scarcely do the work, while two 100 horse-power connected engines would do it easily, provided the quantity of steam were increased.

In this respect it is remarkable that the deficiency is general. Boilers are almost always calculated too closely, and many efficient engines are crippled for want of a full supply of steam. Where the generation of steam is more an object than the first cost of machinery, as on ocean steamers, and where coal is costly, it is a matter of necessity or economy to provide engines calculated to do the most duty with the least amount of steam, as in the Cornish low-pressure engines, or in working steam expansively in high-pressure engines; but in all other cases it is economy to provide an excess of steam-boiler or heating surface. The object in such cases is to make a small amount of fire surface heat a great extent of boiler surface, or to expend the caloric in the most efficient manner.

But in colliery establishments, where coal is plentiful and cheap, the same objects are not directly sought, though it is equally important that a large boiler surface should be provided—not so much, however, with regard to the economy of fuel as to the efficiency

of the power, though a surplus of boiler does not affect the quantity of coal used in an unfavorable manner; in fact, the result is quite the reverse. When there is a deficiency of boiler surface, steam is always low, and the engines cannot do their duty, while an excessive firing simply wastes the heat by passing it up the stack. Therefore, an extra boiler, with fires arranged for the most effective use of the flame and heat, and moderate firing, not only saves labor, coal, and material, but also renders the machinery fully effective.

Large single engines are not as useful in colliery establishments as smaller double connected engines where speed is required, as in nearly all our mining departments, except in pumping; and in this, large, heavy, and slow-moving engines are more useful than smaller and faster ones.

To present the matter clearly, we will state that a 40 horse-power engine, single, moving at 50 revolutions per minute, and consuming 16,000 cubic inches of steam (which is an excess) at 50 pounds pressure, will lift 6000 pounds 300 feet per minute. But two 20 horse-power connected engines, running at 100 revolutions per minute, and consuming 32,000 cubic feet of steam, will lift double the weight, with more ease, 300 feet per minute. In the first instance the pinion or drum should be two feet in diameter, and in the second one foot diameter. But if the pinion remains the same the load is lifted at double the speed. To a certain extent this rule holds good notwithstanding the additional friction of the two cylinders, since the advantage gained by having one crank continually on the *live centre* more than compensates for the additional friction.

The heaviest loads to be lifted from our deep mines should not exceed 7 tons, or, if 10 tons, 3 tons may be counterbalanced by the descending cage and wagon: therefore 200 horse-power ought to be sufficient to do the work of hoisting from any single shaft or slope. But, as before observed, and on the principle advanced in the case of the 40 horse-power or the two 20 horse-powers, two 100 horse-power connected engines would have the same advantage over the 200 horse-power single engine that the two 20 horse-power engines had over the 40 horse-power engine. The load in both cases is, perhaps, more than should be attached. We calculate, however, the maximum duty of a single engine as the minimum duty of two connected engines of the same average power and supplied with a full amount of steam. A 40 horse-power engine will not lift more than 6000 pounds 300 feet high per minute, without great strain, running at 50 revolutions per minute. But two 20s, running at 100 revolutions per minute, will lift a greater load—say 8000 pounds—that distance with ease.

The weight to be lifted in a shaft 300 feet deep may be estimated thus:—coal, 3 tons; car, 1½ tons; cage, ½ ton; rope, ¾ ton,—since the pulleys should be some distance above the landing-point. This would give 5¾ tons as the load. But the cage and car would be counterbalanced, and would thus reduce the weight to be lifted by the engine to 3¾ tons at starting, 3 tons in the middle, and 2¼ at the top of the shaft; since in the middle the rope is balanced, and nothing but the coal is lifted, while at the top the rope counterbalances an equal weight of coal. Therefore the maximum load is 8400 pounds, the average 6720 pounds, and the minimum 5040 pounds. This load can be lifted 300 feet per minute by two 20 horse-power connected engines, if geared to run at 100 revolutions per minute.

In a shaft of 1000 feet depth, the load would be considerably increased with the same coal-car and cage, on account of the increased weight of the rope, and the tendency to render the counterbalance less effective by the increased depth. For instance, a balance with equal weights is poised on common levels, but if the weight on one side is lower than that on the other, the lowest side will always be the heaviest in effect, though of the same weight really: fifteen ounces may counterpoise a pound if the centre of gravity

be not equal, and the same in relation to the counterbalance in shafts. The cars and the cages may be of equal weight, but, one side being 1000 feet lower than the other, they will not be equal in effective weight, even though the additional weight of the rope be added to the upper side. The difference may not be great; still it adds to the load at starting, which is the most trying point to the engine.

We will make our calculations, however, without reference to the unequal poise, and estimate the weight of cars and cages as equal, and, therefore, as counterbalanced. In shafts of great depth it seems proper to raise as much coal as practicable at once: therefore we calculate cars of 4 tons as the maximum; but the size of the cars must depend on the size and dip of the seam. If the seam is small, large cars cannot be used; if the dip is considerable, yet not steep enough to *run*, it would not be convenient to take large cars into the breasts or chambers. The size of the car, and the amount of coal to be raised each time through the shaft, depend on these conditions. A capacity of four tons may be considered a maximum, and one ton a minimum, for a car.

The load in a shaft 1000 feet deep, provided the amount of coal be four tons, may be estimated at 25,000 pounds; viz.: coal 8960 pounds, car and cage 8960 pounds, and a rope of 2 inches diameter, weighing 7.05 pounds to the foot,—7050 pounds,—giving a total weight of nearly 25,000 pounds to be lifted by the rope. But the load on the engine is only the coal and the rope, if we suppose the car and cage to be in equipose: therefore the load which the engines have to start from the bottom of the shaft is 16,000 pounds, in the middle of the shaft 8960, and at the top of the shaft only 1910 pounds. A single engine of 200 horse-power, running at 20 revolutions per minute, would have enough to do in starting such a load and raising it at the rate of 500 feet per minute; but two 100 horse-power connected engines, running at 40 revolutions per minute, would do the work with ease.

In order to equalize the load, and give, consequently, additional power to the engines, flat ropes, winding on narrow drums, increasing the raising drum and decreasing the descending drum, are the best means. The great difference between the power required to start the load from the bottom, or that required from the middle up, is evident. Two fifty horse-power engines would be more effective with flat ropes and narrow increasing and decreasing drums than two one hundred horse-powers with the round and common stationary drum would be.

The same thing, however, may be accomplished by cone drums, having grooves in which the rope must wind in the form of a screw, increasing in diameter on the raising side and decreasing in diameter on the descending side. Thus, the rope might start to raise the load on a six-feet drum and land it on a twelve-feet drum. The objection to this mode is the size of the rope which must be used to raise the load required, and the small dimensions of the drum. A two-inch wire rope should not be wound on a drum of less than 12 feet, particularly on starting with 25,000 pounds weight: consequently, to use the cone drums effectively, the starting or smallest diameter should be 12 feet, and the largest diameter 24 feet, which would be ponderous and costly. But by the other mode, using flat ropes and narrow drums, with the rope winding on itself, this objection would not exist. The decrease in the size of the ropes allows of a corresponding decrease in the diameter of the drums. If the load is started on a drum 7 feet in diameter instead of one 12 feet diameter, with the same proportions of pinions or leverage, the power to do the work is proportionately increased; but, in addition to this advantage, the counterbalance is increased in nearly equal ratio, since the drum is over ten feet in diameter on the descending to seven feet on the ascending side, and the balance in favor of the load is correspondingly increased. The descending car and cage, weighing 8960 pounds, hang 5 feet from the centre of the drum, while the ascending load of 25,000 pounds hangs only 3½ feet from its centre: this would increase

the descending weight as a counterbalance by making it equal to 11,684 pounds, and the ascending load to be lifted by the engine would be 13,352 pounds. Of course something must be allowed for friction, and the loss of equilibrium effected through a set of ponderous machinery; but the above calculation is nearly correct; and hence we gain by this mode of constructing drums and connecting engines over the old mode of single engines and stationary drums not only in first cost, but in effectiveness of machinery and in durability of both ropes and machinery.

BOX CAGES.

There is another mode of raising coal from deep shafts, that may be commendable in some cases. The plan is to dispense with cars and cages in shafts and substitute for them a simple box of boiler-plate, which may hold five tons, more or less. This box does not leave the shaft, but the coal is dumped from the cars into the box at the bottom of the shaft, and on arriving at the top the box is emptied by a contrivance into the shutes of the breaker. This mode may be advantageous where deep shafts are sunk in small seams and where large cars cannot be made use of. In seams of from four to six feet, cars which carry more than from one to two tons of coal cannot be made use of, and where the dips of seams are over 20° large cars cannot be conveniently used; therefore in such cases the box cages may be available, and a much greater amount of coal raised than could be done in one shaft if the cars were raised with the coal. The difference in weight on the engine would not be materially altered, but the load to be carried by the rope would be much less.

The box would not weigh more than one ton, or with four tons of coal 11,200 pounds; consequently, the size of the rope would be decreased from two inches to one and a half inch diameter, the weight of which is about four pounds to the foot, or 4000 pounds to the 1000 feet, instead of 7000 pounds: the weight, therefore, to be lifted by the rope is 15,200 pounds instead of 25,000, as when the car and cage are lifted with the coal, and the load on the engines 12,960 pounds instead of 16,000 pounds.

A smaller shaft can also be made to answer the purpose, in case the boxes are used in place of the cars and cages, since the former would occupy one-half less space than the latter. This mode is in use at the Pioneer colliery at Ashland.

PNEUMATIC MACHINERY.

Perhaps the most simple, economical, and safe mode of raising coal or water from deep mines is the pneumatic process, or by the use of compressed air. We think the first cost of establishing this process would not be much greater than the modes now in use; while the constant operation thereafter would be permanent and cheap.

The mode consists in laying two air-tight tubes down the main slope or shaft, of a size sufficient to receive the cars or boxes designed to carry the coal. If boxes are used, the size of the tubes may be small,—say five feet in diameter; but if cars are used they could not well be less than six feet in diameter, in slopes where the cars ascend end and end; in shafts where the cars go up as they stand, the tubes should be five by ten.

Boxes are to be preferred for several reasons in pneumatic tubes, since they require much less space, and the load to be lifted is reduced by the weight of the car, or two tons. If a tube of five feet diameter be used, the area is 25 square feet, or 3600 square inches: this, at a pressure of five pounds to the square inch, will lift a weight of [illegible] pounds. In order to obtain the pressure, two blowing-cylinders of a capacity of [illegible] cubic feet, to be run at 25 revolutions or 25 double strokes per minute, and at seven or eight pounds pressure—say 7½ pounds—per square inch, are erected on the surface, and two direct-acting high-pressure steam-engines of 30-inch cylinder are placed perpen-

larly below them, so that the pistons of the engines connect with the pistons of the blowing-cylinders. This will give 2¼ pounds per square inch excess of air for escape and contingencies.

Thus prepared, the cages may be made of sufficient size to carry five tons of coal and three tons of water, leaving a surplus of 900 pounds to operate in favor of balancing the boxes, which are connected by a small rope capable of suspending the empty cage from a pulley over the tubes. At 25 revolutions per minute, the blowing-cylinders will produce a third more compressed air than is necessary, by computation, to raise this amount of coal and water 1000 feet high every minute.

This power will raise 1000 tons of coal in ten hours with perfect ease,—giving three minutes time to each load, or one minute for loading, one for ascending, and one for unloading,—and 600 tons of water. While the box is standing the air is accumulating, and therefore compressed ready for instantly throwing up the boxes from the bottom of the mine. In case larger tubes are used, larger loads may be raised with the same pressure per square inch, or the same load with less pressure. The water-boxes are suspended beneath the coal-boxes, and fill themselves from the "sump" while the coal is being loaded into the coal-boxes at the bottom of the shaft or mine, and the water is discharged on the top at the same time the coal is being unloaded.

The whole operation is simple, and governed by valves: there are no pumps or chains or heavy ropes required, and a serious accident is impossible. We do not think the first cost of erecting machinery of this character can be greater than that of the machinery now in use, since the power of the engines would be one-half less than that of the hoisting- and pumping-engines required to do the same work at the same depth; and, although the tubing would be expensive, there would be no outlay for pumps, rods, and timbers, since they would not be required.

SAFETY-CAGES, TRAVELLING-RODS, ETC.

We have not faith enough in safety-cages to try the adventure of descending on them if any other means are presented, and we cannot recommend any invention of the kind as safe enough to risk the lives of the workmen on. It is possible, with proper care and watchfulness, to make several contrivances reasonably safe; but generally when an accident happens they are found out of order. The "drag" in slopes, and the heavy falling bars without springs in shafts, are perhaps the most reliable, when properly made and attached; but these safety arrangements should be designed rather to save property than to save life. The workmen should not be allowed to ride up on the loaded coal cars or cages under any consideration, since the danger is imminent even when every care and precaution is taken. If there may not be a convenient travelling way into the mine, a mode should be provided for their entrance and exit; and the most simple and economical is to attach platforms to the pump-rods. If a single rod is used, platforms are placed at intervals equal to the stroke of the pump, with corresponding stationary platforms on the side of the shaft. The workman steps on the upper platform of the rods and descends to the next stationary one, upon which he steps and remains for the return of the stroke, and then steps on the second platform on the rods and descends to the second stationary one. This process is continued to the bottom of the mine. If the pump makes five strokes per minute and ten feet to the stroke, he descends at the rate of 50 feet per minute, or 1000 feet in 20 minutes.

PUMPING-MACHINERY.

The drainage of deep mines is a question of equal importance with any other consideration in mining matters. To deliver 100 or 1000 gallons of water per minute from

a depth of 100 or 1000 feet requires not only powerful machinery, but reliable and durable fixtures. If we take 500 gallons per minute as the maximum production of our deep mines, and 500 feet as their maximum depth, we still find that the amount of water discharged per day, and the weight of the column to be lifted, are enormous. An imperial gallon weighs over 12 pounds, and a column to discharge 500 gallons per minute should be 20 inches in diameter; the amount discharged in 24 hours would be 720,000 gallons, or 3200 tons, and the column to be lifted by the engine not less than 30 tons 50 feet high per minute. By geared motion, working the engine to its maximum speed, this may be done by 130 horse-power. But the great weight of the load necessitates massive machinery and numerous connections in order to reduce the speed to the slow movements of so large a pump: consequently, direct action is to be preferred to geared motion, by connecting the piston of the steam-cylinder with the pump-rod and making the stroke of cylinder and pump equal. To effect this, a cylinder should not be less than 50 inches in diameter, where steam of 40 pounds pressure per square inch is used, in order that a surplus of power may be provided. A cylinder of this size,—ten feet stroke, —at five strokes per minute, would require per minute about 680 cubic feet of dense steam of a common pressure of 40 pounds per square inch; and a common geared engine of 30-inch cylinder, working at 20 revolutions per minute, would require per minute 750 cubic feet of steam of the same density to do the same work. Thus, when slow motion is required to lift heavy weights, the more directly the steam can act the more economical will be the expenditure of power; but, as noticed in connection with the hoisting of coal, where great speed is required the reverse is the best economy.

In the instance here given of a drainage of 500 gallons per minute, we exceed the general maximum drainage of mines in this country, but are below that of the deep mines of England. The size of the pump given, however, we consider the largest that should be used, or the largest that can be used with economy at great depth. An unbroken column of five hundred feet in length is double the perpendicular height at which a pump can be properly worked, since the pressure per square inch on the valves and working parts should never exceed one hundred pounds per square inch. Two hundred feet is perhaps the most economical and effective height.

Water weighs 62.5 pounds to the cubic foot; a column of water 34 inches in perpendicular height is equal to the atmospheric pressure,—14.7 pounds per square inch.

The Cornish pumps are acknowledged the best or most available for mining purposes; and the Cornish miners, having the most practical experience, have also had the most inducement to direct their experience and ingenuity to the economy of drainage, since their mines are deep and extensive and their fuel is costly. Their pumping arrangements are, therefore, the most perfect known. At the Consolidated Mines, which are 1560 feet deep, from 2600 to 3000 gallons of water are raised 1200 feet high per minute; 4000 horse-power is provided, and about half the power is constantly at work. The whole number of engines is nine. The average duty of the Cornish pumping-engines is about 50,000,000 pounds of water lifted one foot high by the consumption of one bushel, or 80 pounds, of coal; which is about equal to 800 tons, or 179,200 gallons, lifted 500 feet high by the consumption of one ton of coal. This is double the duty of our best Bull engines, and three times the production of our geared pumping-engines.

But, taking into account the simplicity of the "Bull engine," the reduction in first cost, and its permanent and reliable character, with the abundance and cheapness of our coal, we consider the high-pressure Bull engines superior to the condensing engines as pumping-machinery for our anthracite mines.

The Bull engine is a simple cylinder, whose piston connects directly with the pump-rod. If used at a shaft, the cylinder should be directly over the column of pipes; but if at a slope, the cylinder is set with the dip of the seam or the angle of the rods. In some cases this mode of connection is not convenient, and the ordinary connecting rods and

"bob" are used; but, if possible, all indirect connection should be avoided. The steam is used direct to lift the rods, and the pressure on the piston must be equal to or greater than their weight, in order to raise them; and the rods must be equal to or greater than the weight of the column of water in the pipes, since the weight of the rods returning forces up the water; that is, the engine simply lifts the rods, and the weight of the rods lifts the water.

There is another effective mode for pumping water from deep mines, and that is, the direct use of steam in both lifting and forcing water, by which the same column of pumps can be made to throw double the quantity of water now produced. There would be but slight difference in the construction of the pump, and no more liability to derangement.

There is not, generally, more economy in this double-acting mode than in the single-plunger pump, as far as the operation is concerned; the first cost may be reduced, but the chief benefit to be derived is in deep shafts where two columns of pumps cannot be used, and where a single column is not sufficient to drain the mine. In this case, the single column may be made to discharge a double quantity of water by the simple change of the working barrel. We have not seen this mode in use at our mines, but have frequently witnessed its operation in equally trying positions, and can fully recommend it in all such cases as above described.

If a mine produces 500 gallons of water per minute, or even considerably less, it is bad policy to trust its drainage to a single pump of 500 gallons capacity per minute. All mining machinery, no matter how perfect, is liable to accident from various causes, and a few days' delay is sufficient to drown the mine; when the pump is just capable of keeping the water down, any accumulation or delay may overpower its capacity. It is not safe to trust the drainage of a deep and extensive mine to less than double the pumping capacity actually required to keep down the water. Nor is it safe, even with double the pumping capacity, to trust it all to a single engine or a single pump. It would be more economy to erect two moderate-sized pumps in each mine that is designed to be extensive, than one very large pump. This, we think, almost any practical engineer or "sump-man" will endorse.

The breaking of clack-pieces, and the bursting of pipes, are of frequent occurrence where the column is of great perpendicular height, and our mechanics and engineers have a habit of *stretching the lift*, and frequently make one lift do when two lifts are almost indispensable. When we consider the pressure that lies on the valves and pipes even at the depth of 300 feet,—which is one-third more than can be recommended,—we can imagine the liability to derangement and fracture; but the full extent of the pressure that occasionally happens can be fully realized only by those who have seen the bursting of clack-pieces the dimensions and strength of which, by calculation, would bear perhaps ten times the pressure of the column. In working heavy pumps, or, in fact, any mine-pump, it is almost impossible to guard against the "water-hammer," or the accumulation of air beneath the plunger; and sometimes a vacuum is created between the plunger and the water by the strangulation of the valves, or the "wind-bore." The consequence of this is the sudden and violent fall of the plunger, and of the immense weight of the rods, with full force on the water. The force of such a blow cannot be estimated except by its effects.

But both these difficulties may be obviated by a little care and ingenuity. A float in the sump, with a wire and bell, will always give warning when the water becomes low, and a column of gas-pipe from the working barrel will always allow the escape of air, or obviate the danger from the "water-hammer."

In addition to the danger from accidents, there is always a liability to a sudden increase of water,—sometimes from subterranean fissures containing pent-up reservoirs, and sometimes from springs which may be cut by the advancing works; but more frequently from sudden floods or long-continued rains, and the "caving in" of old

workings, which open channels for the admission of the torrents pouring from the mountain-sides under such circumstances.

It is, therefore, best, safest, and most economical, eventually, to have not only double pumping capacity, but two independent pumps each more than capable of draining the mine.

The plunger pump is the only really reliable one for deep mines and heavy pumps,—particularly where the acids of the water have an injurious effect on iron, which is generally the case in coal-mines, where the decomposition of the iron pyrites frequently renders the water so destructive to iron that even cast plungers cannot be successfully used in pumps. We have seen, in such cases, a bar of iron two inches wide and three-eighths thick cut through by mine-water in two weeks. Copper, glass, and wood are resorted to in such cases; but, generally, cast-iron plungers, if kept well greased and packed, are the most available.

In sinking mines, slopes, or shafts, where the water must be sucked from the bottom of the pit, and, consequently, is accompanied by air and gravel, the common *lifting pump* is the only reliable one, and we do not think a better can be designed for the purpose.

A great many new pumps have been invented of late years, and some of them are admirable for certain uses; but, though we have personally examined most of them, we do not find any that can take the place of the old Cornish lifting pump for sinking mines, or of the plunger pump as a permanent fixture. The donkey pump and engine combined is very available under certain circumstances, or where steam can be taken down into the mine without loss by condensation, and where heavy lifts do not occur; but the presence of additional valves, and the necessity for frequent stoppages to change the clacks and pack the pistons, render these pumps unreliable generally for mining purposes.

TABLES AND RULES FOR DISCOVERING THE CAPACITIES OF ENGINES AND PUMPS.

The following is an old rule for obtaining the power of condensing engines:—

Square the diameter of the cylinder and multiply the sum by .7854, the product by 10, and the whole product by 144, which will show the number of pounds the engine will lift one foot high in a minute. Divide the number of pounds by 33,000, and the result will be the horse-power. In the above calculation, the pressure per square inch is estimated at 10, independent of friction, with 9 revolutions per minute and 8 feet stroke.

The example is thus:—

What is the power of a steam-engine the cylinder of which is 50 inches in diameter, and the stroke 8 feet?

$$
\begin{array}{r}
50 \times 50 = 2500 \\
.7854 \\
\hline
1963.5000 \\
10 \\
\hline
19635.0000 \\
144 \\
\hline
\end{array}
$$

$$
\begin{array}{l}
33000)2727440.0000(82{,}344 \text{ Ans.} \\
\quad 264000 \\
\quad \overline{\quad 87440} \\
\quad\quad 66000 \\
\quad\quad \overline{\quad 1440}
\end{array}
$$

2,727,440 pounds lifted one foot high per minute, equal 82 horse-power, with a fraction over.

A better rule for estimating the nominal horse-power of a condensing engine of a constant uniform pressure of seven pounds per square inch is thus:—

Example.

Square the diameter of the cylinder in inches, and multiply by the cube root of the stroke in feet, and the result by .0213; the product is the nominal horse-power.

What is the power of an engine with 30 inch cylinder and 6 feet stroke?

$30^2 = 900$ and $\sqrt[3]{6} = 1.817$: hence $900 + 1817 \times .0213 = 34.8$ horse-power.

The effective power of any engine may be obtained by this rule:—

Find the area of the piston in inches, and multiply the same by the uniform pressure of the steam in pounds per square inch, and the result by the velocity of the piston in feet per minute. Deduct 2½ pounds per square inch for friction, and divide the remainder by 33,000: the quotient is the effective horse-power.

Example.

What is the effective power of an engine whose cylinder is 40 inches in diameter, the piston's velocity 200 feet per minute, and the pressure 40 pounds per square inch?

$40^2 \times .7854 = 1256.64$ inches area and 40 pounds pressure.

$1256.64 \times 40 \times 200 = 10049982$, with friction deducted =

33000)10049982(304½ horse-power.

Having a certain amount of work to accomplish, or a certain load to lift, required the power to lift it at a certain rate per minute.

Rule.—Reduce the weight to be lifted to pounds, multiply by the feet through which the load is to be lifted per minute, and divide by 33,000: the quotient gives the horse-power required.

Example.

Required the power to lift 5 tons 500 feet per minute.

2240 lbs. $\times$ 5 = 11200 lbs. $\times$ 500 = 33000)5600000(169.03 horse-power.

HORSE-POWER.

By numerous experiments it has been found that one horse equals the strength of seven strong men, and also that a horse of common size and strength, working 8 hours per day, will not exert a greater power than 23,412 pounds lifted one foot per minute; if worked only 6 hours per day, 24,360 pounds; if 3 hours per day, 32,943 pounds can be lifted one foot per minute. It will be seen that Mr. Watt's liberal estimate for his steam-engines is fully double the power exerted by a horse working a full day.

STEAM.

One cubic inch of water evaporated under the atmospheric pressure is converted into a cubic foot of steam.

The same amount of water evaporated under the atmospheric pressure gives a mechanical force equal to one ton raised one foot per minute; or steam at a pressure of 10 pounds per square inch and 261° of temperature exerts the same force. To develop one horse-power per minute will, therefore, require the evaporation of 15 cubic inches of water, or 900 cubic inches per hour. If the friction of the machinery, or the power required to move the engine, be 2½ per cent. of the power developed, we must, of course, add that amount to the amount of water required.

The capacity of boilers should not be less than 25 cubic feet for steam and water, with) square feet of heating surface, and 1 square foot of furnace space for every nominal horse-power; and, as before explained, when coal is plentiful and cheap, one-third to one-half more boiler surface may be used with economy with high-speed engines.

Under favorable conditions, about 33 cubic feet of steam should be generated per minute, or one cubic foot of water evaporated per hour, for each horse-power; or one pound of coal should evaporate eight pounds of water.

AIR.

One hundred parts of pure air contain, by weight, 75.55 nitrogen, 23.32 oxygen, and 1.3 carbonic acid. The pressure of the atmosphere equals a column of water 34 feet in height, a column of mercury 30 inches in height, or 14.7 pounds per square inch at a mean temperature. The resistance of air increases as the square of the velocity, and the resistance per square foot as the velocity multiplied by 00.2288.

TABLE

Showing the Square Inches in a Cylinder or Circle from 10 to 73 Inches in Diameter.

Diameter.	Square Inches.	Diameter.	Square Inches.	Diameter.	Square Inches.	Diameter.	Square Inches.
10	78.54	26	530.93	42	1388.59	58	2642.00
11	95.03	27	572.56	43	1452.20	59	2734.00
12	113.10	28	615.75	44	1520.53	60	2827.44
13	132.73	29	660.20	45	1590.43	61	2922.47
14	153.94	30	706.86	46	1661.91	62	3019.00
15	176.71	31	754.77	47	1735.00	63	3117.25
16	201.06	32	804.25	48	1809.56	64	3217.00
17	226.98	33	855.30	49	1885.74	65	3318.31
18	254.47	34	907.92	50	1963.50	66	3421.20
19	283.54	35	962.00	51	2042.82	67	3526.66
20	314.16	36	1017.88	52	2123.72	68	3651.69
21	346.36	37	1075.20	53	2206.19	69	3739.29
22	380.13	38	1134.00	54	2290.23	70	3848.46
23	415.47	39	1194.60	55	2375.83	71	3959.20
24	452.39	40	1256.64	56	2463.00	72	4071.51
25	490.88	41	1320.26	57	2651.76	73	4185.40

TABLE

Of the Expansion of Air by Heat, that at 32° Fahrenheit being 1.000.

Fah.	Volume.	Fah.	Volume.	Fah.	Volume.
35°	1.007	85°	1.121	170°	1.295
40	1.021	90	1.132	180	1.315
45	1.032	95	1.142	190	1.334
50	1.043	100	1.152	200	1.364
55	1.055	110	1.173	210	1.372
60	1.066	120	1.194	212	1.376
65	1.077	130	1.215	302	1.558
70	1.089	140	1.235	392	1.739
75	1.099	150	1.255	482	1.919
80	1.110	160	1.275	572	2.098

Common Gravity of Water.

1 cubic inch weighs	.03617 pounds.
12 cubic inches weigh	.434 "
1 cubic foot weighs	62.5 "
35.84 cubic feet weigh	1 ton.
1 cubic foot of sea-water weighs	64.2 pounds.
34.9 cubic feet of sea-water weigh	1 ton.
1 cubic foot	6.25 imp. galls.
1 cylindrical foot	5 imp. galls.
12 imperial gallons weigh	1 cwt.

224 imperial gallons weigh.. 1 ton.
45.64 cylindrical inches weigh.. 1 ton.
12 cylindrical inches weigh.. .341 pounds.
1 cylindrical foot weighs.. 49.1 pounds.

TABLE

Showing the Weight, Wine Gallons, and Cubic Feet of Water contained in six feet of Pump from four to twenty inches in diameter.

(From Budge's Practical Miner's Guide.)

Diameter of Pump.	Weight.	Wine Measure.			Cubic Feet.	Diameter of Pump.	Weight.	Wine Measure.			Cubic Feet.
Inches.	*Lbs.*	*Gals.*	*Qts.*	*Pts.*	*Feet.*	*Inches.*	*Lbs.*	*Gals.*	*Qts.*	*Pts.*	*Feet.*
4	32.75	3	3	1	0.522	12¼	306.95	36	2	1	4.910
4¼	36.95	4	1	1	.591	12½	319.60	38	1	0	5.113
4½	41.42	4	3	1½	.662	12¾	332.51	39	2	1	5.319
4¾	46.15	5	2	0	.738	13	345.68	41	1	1	5.530
5	51.14	6	0	1	.818	13¼	359.10	42	3	1	5.745
5¼	56.38	6	3	0	.902	13½	372.78	44	2	1	5.960
5½	61.87	7	1	1½	.989	13¾	386.72	46	0	1	6.187
5¾	67.63	8	0	0½	1.082	14	400.90	48	0	0	6.414
6	73.63	8	3	0	1.178	14¼	415.35	49	2	1	6.645
6¼	79.90	9	2	0	1.278	14½	430.00	51	1	1	6.880
6½	86.42	10	1	0	1.382	14¾	445.00	53	0	1	7.119
6¾	93.20	11	0	0	1.491	15	460.23	55	0	1	7.363
7	100.22	12	0	0	1.603	15¼	475.69	56	3	1	7.610
7¼	107.51	12	3	0	1.720	15½	491.42	58	3	0	7.862
7½	115.00	13	3	0	1.840	15¾	507.40	60	2	1	8.117
7¾	122.85	14	2	1	1.965	16	523.63	62	2	1	8.379
8	130.90	15	2	1	2.094	16¼	540.13	64	2	1	8.641
8¼	139.22	16	2	1	2.027	16½	556.87	66	2	1	8.909
8½	147.78	17	2	1	2.354	16¾	573.88	68	2	1	9.181
8¾	156.60	18	2	1	2.505	17	591.13	70	3	0	9.457
9	165.63	19	3	0	2.650	17¼	608.65	72	3	0	9.739
9¼	175.00	20	3	1	2.800	17½	626.42	75	0	0	10.022
9½	184.60	22	0	0	2.954	17¾	644.67	77	0	1	10.310
9¾	194.45	23	1	0	3.110	18	662.73	79	1	0	10.602
10	204.54	24	1	1	3.272	18¼	681.26	81	2	0	10.899
10¼	214.90	25	2	1	3.438	18½	700.00	83	3	0	11.142
10½	225.51	27	0	0	3.607	18¾	719.10	86	0	1	11.504
10¾	236.37	28	1	0	3.781	19	738.40	88	1	1	11.813
11	247.50	29	2	1	3.959	19¼	757.96	90	3	0	12.126
11¼	258.87	30	3	1	4.141	19½	777.78	93	0	1	12.443
11½	270.51	32	1	1	4.327	19¾	797.85	95	2	0	12.764
11¾	280.40	33	2	1	4.518	20	818.18	97	3	1	13.090
12	294.53	35	1	0	4.712						

TABLE OF SPECIFIC GRAVITIES.

Metals.	Weight, Water being 1000.	Number of Cubic Inches in a Pound.	Weight of a Cubic Inch, in Pounds.
Platina	19,500	1.417	.7058
Pure gold	19,258	1.435	.6965
Mercury	13,560	2.040	.4902
Lead	11,352	2.435	.4105
Pure silver	10,474	2.638	.3788

TABLE OF SPECIFIC GRAVITIES.—*Continued.*

Metals.	Weight, Water being 1000.	Number of Cubic Inches in a Pound.	Weight of a Cubic Inch, in Pounds.
Bismuth	9,823	2.814	.3552
Copper	8,788	3.146	.3178
Brass	7,824	3.533	.3036
Iron, cast	7,264	3.806	.2630
Iron, bar	7,700	3.592	.2790
Steel	7,833	3.530	.2833
Tin	7,291	.790	.2636
Zinc	7,190	3.825	.2600

Various Bodies.	Weight, Water being 1000.	Weight of a Cubic Foot, in Pounds.	Number of Cubic Feet in a Ton.
Marble, average	2,720	70.0	13.
Granite, average	2,651	165.6	13.5
Chalk, British	2,781	173.8	12.75
Brick, common red	2,160	135.0	17.5
Brick, Welsh fire	2,408	150.5	14.5
Tallow, average	942	50.0	38.0
Ice from fresh water	1,001	53.0	35.5
Coal, anthracite	1,526	95.3	24.7
Coal, bituminous	1,319	82.4	26.0
Coal, bituminous, caking	1,270	79.3	28.2
Coal, cannel	1,272	79.5	28.0
Coke, dry	755	47.0	47.6

Seasoned Timber.	Weight, Water being 1000.	Weight of a Cubic Foot, in Pounds.	Number of Cubic Feet in a Ton.
English oak	934	58	38.5
African oak	944	59	38.0
Riga oak	872	54	41.5
Beach oak	852	48	45.0
Ash oak	845	52	43.0
Mahogany, Spanish	800	50	45.0
Dantzic oak	756	47	48.0
Riga fir	753	47	48.0
Maple	752	47	47.5
Teak	750	46	48.5
Elm	673	42	53.0
American oak	672	42	53.0
Walnut	671	41	53.5
Pitch pine	660	41	54.5
Red pine	657	41	54.5
Mahogany, Honduras	637	40	55.0
Sycamore	604	38	59.0
Lime tree	600	37	59.5
Cedar	561	35	64.0
Yellow pine	461	28	80.0
Hemlock	450	29	75.0
Cork	240	15	141.0
White pine	426	26	84.2

Density of Gases as compared with Atmospheric Air at 1000.

Carbonic acid gas	1,527
Oxygen	1,111
Heavy carburetted hydrogen	972
Nitrogen	669
Steam at 212°	623
Light carburetted hydrogen	600
Air rarefied by 500° of heat	563
Hydrogen	69

TABLES OF THE WEIGHT OF IRON IN VARIOUS MERCHANTABLE FORMS, IN POUNDS AND FRACTIONS.

Flat Bar and Hoop Iron.

Thickness, in Inches.	Breadth, in Inches.										
	3½	3	2¾	2½	2¼	2	1¾	1½	1¼	1	¾
⅛	1.47	1.26	1.15	1.05	0.94	.84	.73	.63	.52	.42	.31
¼	2.94	2.52	2.31	2.10	1.89	1.68	1.47	1.26	1.05	.84	.63
⅜	4.41	3.78	3.46	3.15	2.83	2.52	2.20	1.89	1.57	1.26	.94
½	5.88	5.04	4.62	4.20	3.78	3.36	2.94	2.22	2.10	1.68	1.26
⅝	7.35	6.30	5.77	5.25	4.72	4.20	3.67	3.15	2.62	2.10	1.57
¾	8.82	7.56	6.93	6.30	5.66	5.04	4.41	3.78	3.15	2.52	......
⅞	10.29	8.82	8.08	7.35	6.61	5.88	5.14	4.41	3.67	2.94	......
1	11.76	10.08	9.24	8.40	7.56	6.72	5.87	5.04	4.20	......	......

Table of a Square Foot of Plate Iron, in Pounds.

Thickness	⅛	3/16	¼	5/16	⅜	7/16	½	9/16	⅝	11/16	¾
Weight, in Pounds	5	7½	10	12½	15	17½	20	22½	25	27½	30

Table of a Square Foot of Sheet Iron, in Pounds.

No. of Wire-Gauge	1	2	3	4	5	6	7	8	9	10	11
Weight, in Pounds	12.5	12	11	10	9	8	7.5	7	6	5.68	5
No. of Wire-Gauge	12	13	14	15	16	17	18	19	20	21	22
Weight, in Pounds	4.62	4.32	4	3.95	3	2.5	2.18	1.93	1.62	1.5	1.37

Table of Round Iron, in Pounds.

Length, one Foot.		Length, one Foot.		Length, one Foot.		Length, one Foot.	
Diameter. *Inches.*	Weight.	Diameter. *Inches.*	Weight.	Diameter. *Inches.*	Weight.	Diameter. *Inches.*	Weight.
1/4	.164	1 3/8	4.961	3 1/4	27.709	6	94.610
5/16	.256	1 1/2	5.913	3 3/8	29.881	6 1/2	110.84
3/8	.369	1 5/8	6.928	3 1/2	32.170	7	128.85
7/16	.503	1 3/4	8.043	3 5/8	34.472	7 1/2	147.68
1/2	.656	1 7/8	9.224	3 3/4	36.895	8	167.94
9/16	.831	2	10.496	3 7/8	39.390	8 1/2	189.54
5/8	1.025	2 1/8	11.846	4	41.984	9	212.53
11/16	1.241	2 1/4	13.283	4 1/8	44.637	9 1/2	236.75
3/4	1.476	2 3/8	14.797	4 1/4	47.385	10	262.34
13/16	1.732	2 1/2	16.396	4 1/2	53.132	10 1/2	290.47
7/8	2.011	2 5/8	18.146	4 3/4	59.187	11	317.48
15/16	2.306	2 3/4	19.842	5	65.585	11 1/2	346.93
1	2.624	2 7/8	21.684	5 1/4	72.618	12	378.44
1 1/8	3.321	3	23.653	5 1/2	79.370		
1 1/4	4.099	3 1/8	25.620	5 3/4	86.781		

Table of the Weight of Square Iron, in Pounds.

Length, one Foot.		Length, one Foot.		Length, one Foot.		Length, one Foot.	
Thickness. *Inches.*	Weight.	Thickness. *Inches.*	Weight.	Thickness. *Inches.*	Weight.	Thickness. *Inches.*	Weight.
1/4	.209	1 1/4	5.219	2 1/8	15.083	3	30.070
3/8	.470	1 3/8	6.315	2 1/4	16.909	3 1/4	35.279
1/2	.835	1 1/2	7.516	2 3/8	18.840	3 1/2	40.916
5/8	1.305	1 5/8	8.820	2 1/2	20.875	3 3/4	46.969
3/4	1.879	1 3/4	10.229	2 5/8	23.115	4	53.440
7/8	2.558	1 7/8	11.743	2 3/4	25.259	4 1/2	67.637
1	3.340	2	13.360	2 7/8	27.608	5	83.510
1 1/8	4.228	...	....	...	....	...	....

WIRE ROPES, CHAINS, AND CORDAGE.

Wire ropes are now generally used in the place of chains and hemp ropes. A greater strength with less weight is obtained by the former than either of the latter. A tarred hemp rope of the best quality, weighing 2 pounds to the fathom (6 feet), and 3 inches in circumference, will not sustain more than 3 tons without great danger of breaking.

Relative Strength of Ropes and Chains, as given by English Experiments on Short Lengths.

Hemp Ropes Shroud, Laid, and Tarred with the Warm Register.	Breaking Strain.		Hemp Ropes Shroud, Laid, and Tarred with the Warm Register.	Breaking Strain.	
	Tons.	*Cwt.*		*Tons.*	*Cwt.*
3 inch circumference.........	3	17	6 inch circumference.........	14	19
3 1/2 " "	5	5	6 1/2 " "	18	02
4 " "	6	17	7 " "	21	00
4 1/2 " "	8	13	7 1/2 " "	24	00
5 " "	10	14	8 " "	27	00
5 1/2 " "	12	19			

Chain Cables, manufactured from best English Iron.	Proof of Bolt.	Breaking of Chain.
	Tons.	*Tons.*
Chain from ½ inch bolt	5½	8½
" ⅝ " "	8½	13¼
" ¾ " "	12	19¼
" ⅞ " "	16¼	26¼
" 1 " "	21½	34¼
" 1⅛ " "	27	48¾
" 1¼ " "	33½	53½
" 1½ " "	48¼	77
" 1¾ " "	65½	105
" 2 " "	85½	137

Chains from best American charcoal iron will bear a greater breaking strain by one-fourth than those made of English iron; but it would not be safe to work them at a higher proof than one-fourth of the breaking proof.

There is a singular circumstance connected with iron not generally understood, or yet scientifically explained. Iron which is cold rolled, or drawn from an annealed or soft condition, will bear a greater direct weight, as bolts or wire ropes, by one-half, than when heated; that is, a wire which will bear 1000 pounds after being drawn through the wire machinery, or, in other words, *new wire*, will bear only 500 pounds after being heated red-hot: therefore a wire rope containing the same weight of iron will bear double the strain which chains will endure without breaking, and may be safely worked at threefold the load that can be risked on chains of the same weight.

Iron Wire Ropes, Charcoal Iron.	Breaking Strain.
	Tons.
Wire rope 1⅞ inches in circumference	6
" 2⅞ " "	15
" 3 " "	19
" 3⅜ " "	21
" 3½ " "	24
Steel Wire Ropes.	**Breaking Strain.**
	Tons.
Steel wire rope 2 inches in circumference	15
" " " 2⅛ " "	16
" " " 2¼ " "	25
" " " 2⅝ " "	28
" " " 3 " "	34

It will be noticed from the foregoing tables that the breaking strain, or the weight required to break a certain length of rope or chain, is not in proportion to weight. A ¾-inch chain manufactured from ¾-inch round iron contains more than three times the amount of iron, and is nearly four times the weight, of a one-inch wire rope, and yet the breaking strain is about the same; while a hemp rope to bear the same strain must be 7 inches in circumference and double the weight of the wire rope. Steel wire ropes will bear four times the burden of an equal weight of hemp rope, and eight times the burden of an equal weight of chain; while the working strain that each will bear is in the same proportion, but in favor of the iron wire over both hemp ropes, and

chains, and still more in favor of steel wire over the iron wire. But if iron or steel wire ropes are heated before use, their strength is reduced one-half. In putting on the sockets at the ends of the ropes, that part is weakened if heated for the purpose, and if short lengths are experimented on they always part at the socket; but in practical working the load is never over one-fourth of the breaking strain, or one-half the resistance at the socket, and, consequently, it is still double the required strength: moreover, the wear and tear, and, in fact, the greatest strain, are towards the upper end of the rope, or that part which winds on the drum, and this part always gives way first.

The following table, furnished by Fisher Hazard, Esq., the Mauch Chunk Pennsylvania manufacturer of wire ropes, gives the relative practical *working dimensions* and strength of hemp ropes, wire ropes, and chains. It will be noticed that the working strain is put at less than one-fourth of the breaking strain; while the breaking strain is considerably less than is obtained from experiment. This, however, is a safe practical test, and may be relied on; for while a piece of chain or rope 12 feet long may bear 80 tons, the same rope or chain 300 feet long might not bear more than 20 tons. The foregoing tables were given to show the relative general strength of ropes and chains: the following one, as a guide to their practical working strength.

Table of Relative Practical Working Strength of Ropes and Chains.

Size, in Inches.			Average Weight per Foot.				Strain per Ton of 2240 Pounds.		Drum.
Wire Rope.	Hemp Rope.	Chain.	Wire Rope. Hemp Centre.	Wire Rope. Wire Centre.	Hemp Rope.	Chain.	Breaking.	Working.	Min. Size.
Diam.	*Cir.*	*Diam.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Tons.*	*Tons.*	*Feet.*
1/2	4	5/16	0.31	0.36	0.50	0.60	3	0.4	2
5/8	5 1/4	3/8	0.59	0.68	0.80	1.36	6	0.9	3
3/4	6	1/2	0.80	0.90	1.20	2.33	10	1.5	4
7/8	6 1/2	5/8	1.05	1.19	1.70	3.66	12	1.8	5
1	7 1/2	3/4	1.43	1.55	2.30	5.33	16	2.4	6
1 1/8	8 1/2	7/8	1.80	2.00	3.00	6.17	22	3.3	6 1/2
1 1/4	10	1	2.33	2.60	4.00	9.33	28	4.5	7
1 3/8	11	1 1/8	2.95	3.20	5.00	12.00	32	5.5	8
1 1/2	12	1 1/4	3.65	4.02	6.25	14.50	36	6.5	9
1 5/8	13	1 3/8	3.79	4.65	7.50	17.66	40	7.5	9 1/2
1 3/4	14 1/2	1 1/2	5.05	5.60	8.75	19.00	45	9.0	10
1 7/8	15 3/4	1 5/8	5.71	6.30	10.00	21.50	50	10.5	11
2	17	1 3/4	6.35	7.05	11.50	24.66	56	12.0	12

It is scarcely possible to manufacture wire ropes with any thing but good charcoal iron, and impossible to make them from ordinary common iron; and the same result holds good to a greater extent with steel wire than with iron wire, since the iron must be good in the first place to produce steel, and the steel must be uniformly good to produce fine wire.

But this is not the case with hemp ropes: almost any kind of material can be

NOTE.—Several of the foregoing tables are from a practical little work on "Steam and the Steam-Engine," by 'illiam Templeton.

made up into ropes of this description in such a manner as to make it impossible to detect the quality and strength of the rope without actual experiment. The same thing may be said of chains: almost any kind of merchantable iron can be forged into chains, and it is impossible to detect the quality without experiment or practice. A $\frac{3}{4}$-inch chain, or one manufactured from $\frac{3}{4}$-inch iron, may stand a breaking strain of 24 tons if made of good iron; but if from poor iron it may snap, without warning, at 5 or 10 tons. In the first case, the chain will stretch considerably before breaking; but in the latter it breaks suddenly without *giving* to the strain. A good link will yield until it becomes parallel or straight before it breaks; but a poor link will snap off without warning. Chains are also apt to give way at the point of welding, if badly made, even with good iron; and when we have both poor smiths and poor iron to contend with or guard against, the danger is great: therefore, in regard to safety as well as economy, wire ropes are far superior to chains, for mining purposes particularly.

The breaking strain of a one-inch wire rope is set down in the foregoing table at 16 tons, and its weight at 1.55 pounds per foot; the breaking strain of a two-inch wire rope is 56 tons, and its weight 7.05 pounds per foot: consequently, the relative strength is in favor of the small rope as to its weight, and indirectly, as to use, it is much more in favor of the small rope, since the bending backwards and forwards over a drum, even of large diameter, is more injurious to a large rope than a small one. It would require 4.75 feet of one-inch rope to weigh as much as one foot of two-inch rope: consequently, the breaking strain of four and three-quarter one-inch ropes would be 76 tons against 56 tons as the breaking strain of a two-inch rope; or four one-inch ropes would bear a breaking strain of 64 tons,—8 tons more than a two-inch rope,—and, if worked together as a *flat rope*, would last double as long as the larger rope.

Flat ropes, therefore, are stronger and more durable than round ones of the same weight, and are to be preferred for colliery purposes. The great difficulty seems to be in their wear together. If not carefully put together, one may bear much more strain than the other; but this difficulty can be obviated either by the manufacturer or the operator. Great care should be taken in putting on the sockets: if done at the mines, the rope should be stretched powerfully and carefully, in order to equalize the strain. If this is done, and the rope well put together, it will outlast two round ropes of the same strength.

Another objection may be raised in the lapping of the rope around the drum; but the true principle is to lap the rope upon itself on a narrow drum or wheel, just wide enough to receive the breadth of the flat rope. The abrasion in this case is not greater than it would be in a round rope, which abrades powerfully against its own side as it winds on the drum. The winding of a flat rope is directly on itself, and the abrasion is, therefore, less than that of a round rope, which winds against itself with a powerful rubbing process, on account of the indirectness of the pull. In this respect the advantage is with the flat ropes and narrow drums. But there is also another advantage in starting loads from deep mines, with small drums increasing as they draw near the top. This is a great help to the machinery, as the load, though of equal weight, exerts a much greater strain on the machinery and rope at 600 feet distance than at 300 feet, independent of the increased weight of the rope at the greater depth. Six hundred feet of two-inch rope will weigh nearly two tons. To start this with a load of eight tons gives ten tons at the greatest depth and nine tons at half the depth. But the effect on the machinery is much greater, since it requires as much power to start 8 tons at 600 feet as 10 tons at 300 feet distance. With the common 12-feet drum required for a two-inch round rope, the leverage of the pinion is just the same through all the drag,—as much at starting as on stopping. But with the flat rope and narrow drum, starting at 6 feet diameter and ending with 8 or 10, the leverage or power of the engine is much greater at the commencement than at the end, on the same principle that it is easier for

a man to work a windlass with a six-inch drum than one with a twelve-inch drum. But in the case of the flat-rope colliery drum, the diameter increases as the rope winds on, and as the weight of the load decreases.

We have no doubt that a good steel wire rope of three-quarter inch diameter, in a band of *four* ropes, would be much more powerful than a round rope of two inches, and that it would wear out at least four round ropes; while the advantage given to the machinery would save several thousand dollars in the first cost of the power, and be the source of constant saving in the generation of steam.

Powerful machinery, with large drums and large round ropes, is very effective and available at our large colliery establishments. Steam is not so much of an object, since coal is plentiful and cheap; but simplicity, permanence, and reliability are important considerations, and should have the precedence over all other questions in mining economy. We do not, therefore, advance the above as a dogmatic rule, but simply suggest the availability of the mode proposed as equally permanent and reliable with the best machinery now in use at the anthracite collieries, and as possessing greater lifting power with less steam and mechanical strength and more economy. We do not propose to recommend any mere theoretical project, but such improvements as tend to simplify and economize.

Of course, hemp ropes are now obsolete in mining economy as a general thing, since they bear no comparison to wire in cost, weight, or effect; and chains are still more objectionable for deep mines and heavy weights, however they may be made; while bands of steel or sheet iron are not much better, and are objectionable in all mining operations: therefore wire ropes are in all respects superior.

A chain capable of drawing 10 tons from a depth of 600 feet would weigh over 14,000 pounds, or 10,000 pounds more than the weight of a wire rope to accomplish the same purpose; while a steel rope to draw an equal load from the depth of 1000 feet would weigh 4000 pounds less than an iron wire rope for the same purpose.

We make the load of 8 tons as the maximum in our deep slopes. It would be unnecessarily heavy in a deep shaft,—say 1000 feet. At such a depth a wire rope of two inches diameter would weigh 7050 pounds, or over three tons. If we add to this 7 tons as the weight of coal, car, and cage, it would still make a load of ten tons to start with, which is as much as a two-inch rope ought to be subjected to at that depth, as much as the heaviest machinery yet built in this region for mining purposes is capable of doing, and as much as it is desirable to lift at one time.

Foreign Lineal Measures compared with the Yard English.

One yard English			English yards.
	= .9148 French metres,	or one metre	= 1.0987
	= 1.5958 Hamburg ells,	or one ell	= .6210
	= 1.4567 Denmark ells,	or one ell	= .6865
	= 1.5400 Swedish ells,	or one ell	= .6493
	= 1.3710 Prussian ells,	or one ell	= .7293
	= 1.2857 Russian arshines,	or one arshine	= .7778
	= 1.3521 Turkish pikes,	or one pike	= .7396
	= 1.1735 Austrian ells,	or one ell	= .8522
	= .4327 Neapolitan cannes,	or one canne	= 2.3111
	= 1.5387 Leghorn braccia,	or one braccia	= .6492
	= .3657 Genoese cannes,	or one canne	= 2.7345
	= 1.0783 Spanish varas,	or one vara	= .9274
	= .8345 Portuguese varas,	or one vara	= 1.1984

Table of the Relative Indications of Barometer and Thermometer at the boiling points of Fresh Water.

(When the barometer indicates 30 inches, the boiling point is 212° Fah., and 0.589 of barometric pressure corresponds to a difference of 1° Fah.)

Columns of Fresh Water in feet equal to columns of Mercury in inches.	Barometer, Height of Mercury in inches.	Thermometer, Degrees of Fahrenheit.
35.07	31	213.57
34.50	[illegible]	212.79
34.02	30	212.00
33.37	29.5	211.20
32.81	29	210.38
32.22	28.5	[illegible]
31.84	28	208.69
31.11	27.5	207.84
30.52	27	206.96
	In a vacuum, water boils at	98.00 to 100

OUTSIDE FIXTURES AT MINES.

At all mines, where large amounts of material are handled, elevation is required for the purpose of transhipment or preparation. At coal-mines, and anthracite mines in particular, considerable elevation is required, in order that the coal may pass through the processes of breaking, cleaning, and separation without handling. This is a great item in the economy of mining. All handling of coal by manual labor should be avoided as far as practicable. We do not think there can be any case in which coal need be handled more than once, and that is by the miners when it is first excavated in the breasts. There are a few instances in which even this handling is not required: as, where the coal is worked by the mode known as the "*run*." But generally the coal must be handled once. It is thrown by hand into the mine-cars, when those cars go into the breasts in flat seams, and from thence passes direct to the "breaker." If the top of the drift, tunnel, slope, or shaft be as high as the top of the breaker, no more

Fig. 150.

INSIDE VIEW OF BREAKER.

elevation is required; but if below, the cars are elevated by machinery to the proper height, and the cars are emptied or "dumped" in the upper, or receiving, shutes or bins of the breaker. From this point the coal descends by gravity through the breaking-rolls and the screens to the bins which contain the prepared coal; from thence it is drawn into the railroad-cars for shipment to market. In the process of passing through the breaking and cleaning machinery, great care should be taken

to separate the *slate* and *bone* from the coal, which must be done by hand; and on the care with which this is done depends the purity of the marketable coal. It is true that a great difference exists in the purity and cleanliness of coal as it comes from the mine, since some seams contain much more slate and bone than others, as may be noticed in our sections of coal, and even the same seam frequently varies in this respect. But all coal contains more or less of these impurities, generally in the body of the seam itself, but often from the top or bottom slate. It is, therefore, of the greatest importance that provision should be made in all coal-preparing establishments for *picking* out the slate and bone. This must be done; and the economy and thoroughness with which it is done depend as much on the means provided as on the care which is taken.

A great many boys are usually employed for this purpose, and, unless under the care of a steady and sensible man, they are not as industrious and watchful as the case requires. In winter, during cold days, the little "*slate-pickers*" have a hard time generally, and but little can be done as our breakers are generally arranged. Stoves are sometimes used; but these are not only dangerous, but far from effective, since the boys must go to the stove frequently in order to keep warm. The best plan is to warm the "slate-pickers'" apartment by means of steam-pipes. A few gas-pipes passed near the boys are the most effective for the conveyance of steam.

HANDLING AND ELEVATION OF COAL.

To return to the handling of coal, we would notice particularly the economy of this item. As before observed, there is no case in which coal, when mined on a large scale, need be handled more than once. When the cars go to the miner in the breasts, we have shown the course it takes. When thrown into the cars by the miner, it is handled no more until it goes to the market,—perhaps to Maine or California. When worked by the *run*, it is not touched by the hand of man, with rare exceptions, until it goes to the cities. When worked by breast and shutes, it need be handled only once, as in the case of breast and cars.

The coal is thrown by the miner or his assistants into the shutes, and slides down the incline of the shutes by its gravity into the cars at the bottom. There are instances where the dip is not steep enough for this, and a second or third handling is required to get it into the cars; but in all such cases we think it better to take the cars into the breasts. Of course, from the cars there need be no rehandling. It goes through the process described.

In a mine from which 1000 tons per day are expected, a second handling not only interferes to a great degree with the amount of work to be done, but increases the cost largely. Outside, when circumstances are favorable, a man may handle 20 tons of coal, but in the mines 10 tons is a good day's work; and, generally, including superintendence, oil, tools, and interference with the transaction of business or the amount of work to be done, this rehandling will not cost less than 15 cents per ton; but, in order to be within the limits, we will estimate it at 10 cents per ton, and we will find that this simple item—which operators do not notice—costs them ($100) one hundred dollars per day on a business of 1000 tons per day.

In these little items lies the success of mining, very frequently, and they often depend on the manner in which the mines are laid out and the manner in which they are worked.

In the outside arrangements many large items of expense are incurred without notice by the proprietors, unless they are practical men. We have frequently seen three men employed where one would have done much more work by the aid of the least bit of ingenuity. We will give a few instances out of many we have seen.

A heavy car comes to the top of the shaft, and this must be removed to the breaker, which is 30 yards distant. The grade is level and the curve of the track great, with rails of equal height. It requires four men to push the car to its place and *dump* it, and two minutes are consumed in changing the cars; perhaps the same thing happens at the bottom; and thus not less than five minutes are taken up with each car of coal,—say two tons.

Now notice the difference. By elevating the car six inches higher and raising the off rail in the curve a little higher than the inside one, and by a simple contrivance on the "cage," the car leaves the cage and runs by its own gravity to the dump, and one man can manage it and change the cars in half a minute. Here we not only save about five dollars per day for labor on the top alone, but the business of the colliery may be more than doubled, which is enough to "*break* or *make*" a concern, when all the machinery and contingent expenses remain the same.

But at the same place there may be, *and are*, other items equally expensive and objectionable. The top of the breaker is limited for height and space, and there is not room to dump more than two or three cars. The men whose duty it is to put the coal into the breaker are crowded together, and cannot do half their duty. They put every thing through the breaker. A rock, which might be thrown out easily, is broken into a hundred fragments and mingles with the coal. Much of it remains there; and what may be picked out is with great labor and expense.

The coal comes out of the mine faster than it can be *handled* on top of the breaker, and the machinery must wait, the men on top must wait, and half the men in the mine must wait. Instead of 500 tons of coal being mined and prepared per day, at a cost of 70 cents per ton, less than 300 is done, at a cost of $1.25 per ton.

These items may be carried out from the miner through all the processes until the coal reaches the cars for shipment to the markets; and instead of two or three instances we might name and describe a dozen or more,—not all at one mine, or no concern could bear the expenses; but generally one or more of these "*profit and loss*" items are to be observed at each establishment.

MINING ECONOMY.

The economical mining of coal depends on the facility with which it can be taken from the miner to the top of the breaker.

First.—The mine should be so planned and laid out as to enable the miner to work with security and in a pure atmosphere; which can be done only by a system of ventilation like that described in the preceding pages.

Second.—It is equally essential that the plans of working be so arranged that the miner can cut his coal with the greatest ease, and put it into the cars with the least amount of labor. The difference in this item ranges from 20 to 50 cents per ton in the anthracite mines,—depending on the size and character of the seam, and the manner in which it is mined.

Third.—To the operator and proprietor there is an interesting question concerning the amount of coal which can be obtained from an acre of ground. When the mines are opened, gangways and headings driven, railroads laid; in fact, all the expensive *dead work* done, and machinery erected,—to do which and keep the same in operation includes about one-third the expense of mining,—it is important that all the available coal opened should be obtained.

If the coal cost 50 cents per ton to mine and deliver on the top of the breaker, provided 30,000 tons per acre be mined from the Mammoth of 25 feet thickness, it will cost 70 cents per ton on the long run if only 20,000 tons are extracted. This may appear paradoxical; but a little figuring, or, better, some experience, will be convincing. We consider the "boundary plan," as described in this work,—a modification

of the English "board and wall" and "long-wall" modes,—the best and most economical that can be used.

FOURTH.—The facilities provided for the conveyance of the coal from the miner to the top of the breaker are important items. Good inside roads, easy grades, and room for the passage of trains, are all items deserving attention. The size of the cars depends on the size and dip of the seam, and may be from one ton to four tons in capacity; from two to three, however, may be the most economical, since they must occasionally be handled by men.

At the bottom of the slope or shaft, arrangements should always be made for the easy and rapid transfer of the cars,—the empty one coming down, and the loaded one going up. The same arrangement should be made at the top of the slope or shaft, so that the cars shall move by their own gravity, not requiring manual labor to start them from their position.

FIFTH.—Elevation of the breaking, screening, and separating machinery is essential. An elevation of from 50 to 75 feet is generally required. A shute or bin above the *rolls* or breaker proper is desirable to hold the coal on coming from the mines, and to give the laborers opportunity to select the coal in the lump, and pass the required kinds and sizes through the breaking-rolls. *Screens* should also be provided to separate certain portions of the coal. Steamboat and lump coal, of course, need not go through the breaker, unless a large amount of steamboat coal is required; neither should that portion of the coal which is already small enough go through the breaker-rolls. By providing for those sizes, much waste and some labor may be saved, and the crowding of hands will be avoided; while the slate and impurities may be separated from the coal in the rough, or before they are shattered and scattered by the breaking process. The separation of the dirt from the coal, and of the small coal from the large coal, also facilitates the selection of the *rock*, *slate*, and *bone* from the coal.

SIXTH.—The foregoing embrace the principal items of economy in mining, as far as the design and style of works are concerned; but perhaps the most important item, after all, in the economy of mining, is efficiency of management. Energy and constant attention are required in all cases; but these qualities are second only to judgment and experience. We have often noticed the great difference in the cost of mining and preparing coal, under the same circumstances and conditions in seam and general availability, in two collieries, owing to the difference in management.

In one case we see the greatest activity and energy displayed, but, unfortunately, *leaks* that can only be seen by experienced eyes are making sad drainage on the profits. In another case we notice a calm, almost careless expression and action, but we see the greatest order and system in the operation, and no item that could be improved or expense that could be saved.

A large amount of the work done in the interior of the mines can be done with more economy by *contract work* than by *day's work*. Miners, like most business men, look sharper to their own interests than to other people's. They may do a fair day's work for one dollar and fifty cents, but they will do more if they can make three dollars per day by contract. Now, it happens that coal-miners will ask one dollar per wagon or car for cutting coal, if they can get it for asking, and they will often say that they cannot do it for less; but the experienced manager *knows* it can be cut for fifty cents, and he will not give more. A yard of gangway may be driven for five dollars, but the miner may want seven dollars and fifty cents, and may not accept less; whereas some one else may take it and make good wages at five. Breasts may be driven by the yard under contract,—say 20 yards wide,—but, if the miners are not watched, they will contract them to 15 yards; and thus, if the coal be 30 feet thick, 50 tons of coal will be lost to the proprietor, which may be worth to him 50 dollars, under the circumstances.* These

* Our mining friends will see that we understand their "tricks and their manners;" but we must say that many of them are too honest to be *smart business men*.

are only a few out of hundreds of instances which might be named in which judgment and experience are of more importance than energy and action; but when all are combined in the management, we find the result in profits.

LOCATION OF OUTSIDE IMPROVEMENTS.

On this subject we shall be brief, not because of its insignificance, or that it can be intelligently discussed in a few words, but for the simple reason that nothing short of an elaborate discussion could present the importance of the subject in a comprehensive or valuable shape.

The outside improvements of our large colliery establishments cost from $50,000 to $150,000,—depending on the amount of business to be done, the character of the plan adopted, and the nature of the location.

It too often happens that a set plan, from which there is no deviation, is made to answer every type of location, ignoring entirely every natural advantage which may be offered, the consequent result being a vast addition to the first cost, and a continual disadvantage in the operation. The object to be accomplished is economy in first expenditure and future operation; but if both can be accomplished, it is the duty and business of the engineer to see it done. Therefore, while a general and tried system of improvements may be followed, the natural advantages or disadvantages of the location should be duly considered, and either be made use of or provided against. How this may be done can perhaps be best learned from seeing how it has been done,—not in any one locality, but in many localities. If all the improvements made use of at the various collieries throughout the anthracite regions could be blended in one, we might expect a model operation. It is scarcely possible, however, for this to be done; but we know of many mining establishments that would have been much more convenient and more economically worked with certain additions or alterations which we have seen elsewhere. We cannot point out those instances without invidious mention and comparison, and will, therefore, only call attention to the subject in general. But, in order to make clear our meaning on this subject, we will state an instance, to show how natural advantages may be made use of.

A colliery was erected on a comparatively flat seam of coal. It was found, however, that the seam dipped more rapidly towards the centre of the basin, and that it would require a deep shaft to reach it, and that, when reached, only a portion of the coal could be obtained conveniently by breasts, or where the dip was sufficient; and that above the brow of the dip could only be brought down by inclines to the bottom of the shaft; or one portion of the mine—say 50 yards—above the shaft could be worked only by "breast and shutes," and the other portion—say 150 yards—could be worked only by "breast and cars." Still, the true mode of working this coal did not occur to the management. The location of the breaking establishment was changed from a fine natural site to one presenting many disadvantages, and a shaft was sunk to the coal on one side of the breaker, and a tunnel driven on the other.

The distance to the brow of the dip was not over 50 feet across the measures; or a shaft 50 feet deep, at an angle of 50°, would have reached the seam at a point where a perpendicular shaft could not be sunk, on account of the face of the hill. This short, sloping shaft would cut the coal on the brow, where 150 yards of breast, or an average dip of 15°, existed, and which could be mined with cars in all the breasts with much economy. Now, let us see the difference in first cost. The perpendicular shaft is about 150 feet deep, costing at least $10,000 more than the sloping shaft would have cost; the tunnel cost $7000, and the additional cost of breaker and machinery more than would have been required by the former mode, not less than $10,000.

Thus, we have $27,000 as the increased cost by adopting this mode. The business

done may be placed at 200 tons per day from the shaft, and the additional cost not less than ten cents per ton over what would have been the cost in case a sloping shaft was used, from the greater drainage, the greater elevation, and the inconvenience of mining under the complicated system inevitable in the case of a deep shaft.

If a sloping shaft across the measures had been adopted, all the coal could have been elevated direct to the top of the breaker; but, by the plan made use of, the coal from both tunnel and shaft was elevated to the top of the breaker by independent machinery. Therefore, we think ten cents per ton a low estimate for the additional cost entailed on a business of 200 tons per day, and one which would last as long as the colliery at the present level, which cannot be short of ten years. Thus, we find this error of location entailing not only a yearly expenditure of $6000, but limiting the business to a small capacity, besides necessitating the increase of the original capital and its interest.

There are many other instances of error in location which betray a greater want of experience and judgment than this, but we must let this one suffice for all.

COAL-BREAKING MACHINERY.

Where a large business is done, the saving of five per cent. in the waste of coal by breaking effects a considerable saving in the year, and this can be done in most cases. On 500 tons per day this amounts to 25 tons, or 7500 tons per annum, which is worth from $1.00 to $1.50 per ton at the top of the breaker. We think some of our improved breakers effect at least this saving over others; and in some cases we have no doubt that the waste is ten per cent. greater than it should be, with proper care and provisions. We think the waste occasioned by the *crushing* of coal in rollers ranges from 10 to 20 per cent. of the whole shipments, as a general rule: we include in this estimate

FIG. 151.

VIEW OF COAL-BREAKER.

pea-coal. In cases where *all* the coal goes through the rolls, the waste is greater, and may reach, in a few cases, 25 per cent. of the entire production of the mine.

The first care should be to put as little through the breaker as possible. All that may be judiciously saved—as lump and steamboat—may be kept out of the *crushers*, and all that is already small enough should be passed down to the screens without going through the rolls, since the greater the mass that is rushed through, the greater will be the waste. Even a cargo of prepared coal put through the second time would lose by the operation from one-fifth to one-tenth of its bulk in pea-coal and dirt, depending on the volume with which it was fed into the rolls.

Therefore, only the coal which is required to be reduced should be passed through

the breaker, and the rolls should be constructed with as little crushing tendency as possible. The best breakers we have seen are the "HAWK-BILLED*" rollers, and the Dickson wrought-iron rolls with steel teeth. The hawk-billed rolls may be made with sharp, *chilled teeth*, and the Dickson rolls can have the teeth sharpened whenever required.

We think either of these patterns would effect a saving of at least five per cent. over the old form of segments and dull, short, cast-iron teeth. The knife-edged teeth are also better than the old-fashioned square teeth.

To do the large business required in great colliery establishments, it is difficult to find any motion so available for coal-breaking as the rotary. A great many other modes have been suggested and tried, but we have not yet seen any which are so effectual.

There has, however, been very little inventive talent brought to bear on this subject. The fate of the first inventor of coal-breakers is not an encouraging example to others. We think the coal-trade have paid pretty dearly for their opposition to the celebrated breaker patent, however exorbitant its demands, from the fact that we continue to crush our coal to an extent that will be sadly felt when our mines are exhausted, and our mining villages deserted, while mountains of refuse stand as their monuments. Had the inventor been encouraged, we have no doubt the case would have been different, since there is plenty of room for improvement.

WASTE AT THE ANTHRACITE MINES.

If we take fifteen per cent. as the average waste of our mines in dust or refuse coal (and this is a low estimate), we find that we sustain a loss of one and a half millions on a business of ten million tons per annum. This immense amount of waste is constantly being piled up around our mines in vast, unsightly mounds, burying our mining villages, and sadly encroaching on the limits of our chief towns. Those who are familiar with St. Clair will remember the mountains of coal-dirt which almost encircle it, and which encroach even on its streets.

The amount of this waste that now lies around our coal-mines cannot be short of 15,000,000 tons, and each year adds to the rapidly accumulating dirt-banks, though every flood of rain carries off a portion to our cellars, streets, canals, and rivers. It will become a necessity in time to find some mode of disposing of it.

There can be no doubt that it can be made use of, and perhaps with much profit and advantage, if capital and enterprise could be diverted from the coal-mines to the *coal-banks*. The amount of money required to put up a first-class colliery capable of mining and shipping 500 tons a day, would erect machinery powerful enough to compress even anthracite coal-dust to a state almost as solid as when it existed in its bed beneath the mountains; and perhaps the amount so consolidated per day would not be less than could be obtained from the mine. Anthracite coal-dust can be solidified by pressure without the admixture of any foreign ingredient; but the pressure must be powerful. An admixture of ten per cent. of wet peat, or of five per cent. of fine clay, will help the solidification, and make the blocks more tenacious and durable. The amount of ash or residue would not be greater than that left by the consumption of ordinary coal, since the combustion is more perfect, and no cinders or unburned embers are left.

But, when circumstances will admit, an admixture of fifty per cent. of the rich bituminous coals will make a better fuel, and require no other adhesive substance than the bitumen which the bituminous coal contains, which is brought into an oily state by heat. By mixing half-and-half of the anthracite dust with fine or pulverised bituminous coal, and pressing them with great power in a hot state, the solidification will

* The only difficulty with this style of teeth is their liability to crumble or break off, if not made with care. We have heard no complaint, however, on this score.

will be complete. But the pressure required is much greater than may readily be imagined by those who have not tried the experiment. The writer instituted a series of such experiments, at considerable cost of time and money, some years ago, and speaks from practical operations. Perhaps the best place to establish such a business would be near some large city, where either clay or bituminous coal can be had more readily than around the anthracite mines, and the anthracite dust can be transported cheaper in that condition than when formed in blocks ready for fuel.

Coal-tar and coal-oil have been proposed, and the former is used extensively in Europe to produce composition fuel. Coal-tar is certainly as good as bituminous coal, but we do not think it could be obtained in sufficient quantities and at a cost to justify its use for such a purpose.

Bituminous coal is always accessible at reasonable cost, and the fine coal can always be had for considerable less than the lump coal,—enough so, in fact, to pay for the operation of compressing. The Richmond (Virginia) coal is the most available for such a purpose, on account of its fat and bituminous character, and may be mined and brought to Philadelphia cheaper than the coal from our anthracite mines, by the same outlay and enterprise displayed by the anthracite miners, since the coal is only 15 miles, on an average, from tide-water on the James, or not more than the average distance of our anthracite mines from the head of navigation on the Schuylkill or Lehigh, or the head of the leading railroad lines to Philadelphia.

We have no doubt of the feasibility of the plan here suggested as a means of converting our immense heaps of waste into an excellent article of fuel, with much profit to those who might engage in it, provided they put capital enough in to insure success. Such a "mutual coal-consumers' company" would stand better chances of their winter's fuel and of reasonable profits than many which have been blindly and foolishly gone into by the coal-consumers of the Eastern cities.

USE OF WASTE COAL AND ORES IN BLAST-FURNACES.

The use of waste anthracite coal in connection with the dust or refuse ores in blast-furnaces is an invention of the writer, on which a patent is pending.

The waste coal is passed through a screen, and the clean dirt, as free from slate and impurity as it is possible to make it, is crushed between heavy, smooth rollers until it is perfectly fine, and in this condition is ready for admixture with a proper quantity of iron ores.

The finer particles of the ores rejected by our large blast-furnaces are collected, with such cheap ores as may be available from the anthracite mines or other localities, and the whole passed through heavy, smooth, iron rollers, and crushed to powder. In this condition it is passed through a stream of water in which it is violently agitated, and then allowed to precipitate in successive tanks. The richer ores will be the first to precipitate, and the most distant sediments will be the leanest. In this manner, ores of any given richness can be obtained from a lean matrix or seam, and the only objection against their use will be their cost, or the cost of mining, since the cost of crushing and precipitating is merely nominal. But the washing and precipitating will not be necessary with rich ores. Such have only to be crushed. In the condition above described, the ores are ready for admixture with the coal-dust in such proportions as experience may dictate, but not above one part of coal to one of ore or flux.

The third process is to burn and slack a sufficiency of lime for flux, and mix the whole in given proportions in the state of brick mortar. The mass can then be moulded by hand as bricks are moulded, and dried and stacked away for use; or they can be made and pressed in machinery, and stacked away to dry without the process of sun-drying.

When sufficiently dried, the blocks are ready for the furnace, and the materials are so intimately mixed and so minute in particles that the carbonizing and deodorizing process is complete, and the burden arrives at the melting zone in a state ready for fusion.

This process has been tried on a small scale and found to work admirably; but it is here mentioned only as a means to economize the waste of the anthracite mines.

We expect most of our extensive coal-operators will be pleased to give away the waste coal, provided it is taken without cost or inconvenience to them. The cost then will depend on the transportation and the preparation of the material. The cost of crushing and mixing would not exceed 50 cents per ton, and five tons would be required to produce one ton of iron. One ton of fine ore yielding 45 per cent., and two tons of lean ore yielding 30 per cent., would, when crushed and cleaned, be less than 2½ tons, yielding an average of 40 per cent. of metal in the furnace, at an average cost, delivered on the ground, of $2.50 per ton.

The lime might cost $3 per ton to transport and burn. The whole cost of a ton of metal would stand thus:—

Three tons of ore delivered	7.50
Half a ton of limestone, burned	1.50
Five tons of coal, ore, and lime, mixed	2.50
Labor, &c.	2.50
Cost per ton	$14.00

This, under ordinary circumstances, might be reduced one-fourth, since the figures above are all given at maximum rates. But, at the full rates for the best ores, the margin lies in the difference in the price of coal, since the preparation of the five tons of mixture would not exceed half the cost of coal as now used in the furnaces.

CHAPTER XXV.

MINE SURVEYING AND ENGINEERING.

The Compass—Mining Superintendent—Plan of Mines—Abandoned Mines—Danger from Water—Our Anthracite Fields a Monopoly to the State—Keeper of the Records—Topographical Plan—Horizontal or Working Plan—Longitudinal and Traverse Plans—Mine Surveying—Surveying without the Magnetic Needle—Construction—Tables—Converting Angles to Bearings—Hypothenuse Radius—Perpendicular Radius—Base Radius—Plane Trigonometry—Problems—Petersburg Mine—Vertical Surveying—Measurement of Heights—Horizontal or Traverse Surveying—Shafting—Sloping—Tunnelling, &c.

In this chapter we will try to present, in a clear and comprehensive manner, a system of mine surveying or dialling which should be understood and practised by every superintendent of extensive mines where professional engineers are not employed. But no man is fully competent to design and operate an extensive mining establishment who has not the ability to put his plans on paper and verify them by mathematical demonstrations. To do this, the compass must be used, and used correctly. In all the operations of mining, this instrument is frequently required. Without it there is no certainty, and but little order. If the superintendent or inside manager cannot use the compass, there is always danger of confusion and error. A professional surveyor is not at home in the mines, and is only taken inside once a month, or perhaps not so often, and then more for the purpose of plotting the mine than for the purpose of laying out the work and keeping it in order.

But we need no argument to prove the utility of this art, and its value to mine engineering. It is indispensable, and should be part of the education of every mining manager or superintendent. By mining superintendent we mean the agent or manager who is responsible for the mining operations.

The professional engineer of mines should, of course, possess a wider range of the engineering sciences than this short chapter on mine surveying will present. However important it may be that he possess the practical information required for the designing of mines, and however certain it may be that they are generally deficient in this part of their profession, we cannot suppose them deficient in the use of the compass or in civil engineering. We do not, therefore, write for the purpose of informing professional mining engineers on this branch of our subject, but for the instruction of that extremely useful profession, the mining superintendent, who must be supposed to be in possession of the practical, however deficient in the scientific, branches of his business.

We will, therefore, use plain language, and try not to go beyond the depth of ordinary comprehension, since we write for the instruction of those who know little of the art of surveying or mine engineering; those who are *au fait* of the science must not expect to find the matter treated in a strictly professional manner.

We propose, however, to follow "Budge's Practical Mine Surveying," as the clearest exposition we can find on this subject; and the tables, diagrams, and examples are mostly from his work. In some cases the mode may be different from that generally used, and some of the rules may be old, but for the learner or the practical miner they will be found more easy to acquire and practise than the more elaborate, though more perfect, instruments and tables of the profession, as now adopted.

PLANS OF MINES AND MINING PROPERTIES.

It is not only useful, but necessary, that plans should be made and preserved of all mining estates and mining operations. They not only present the whole scheme of operation to the eye and the mind, bringing the facts and natural advantages to a focus, and thus suggesting the course and mode of operation, but also present a record of the workings indispensable to the management, and important and instructive to all interested.

All mining operations are to a certain extent intricate; and, while it is possible for a manager, who planned and executed the workings, to retain a good general impression of all the avenues, headings, air-courses, breasts, &c. in the mine, he cannot be sure of his points, or fail to fall into confusion by frequent changes of dip, which we so often meet with. But even if he could retain all this in memory, and provide against derangement, he cannot transmit those "memories" to a successor, or convey to others, and perhaps to those most interested, any clear impression of his works, plans, or intentions. It is, therefore, indispensable that plans of mines should be made, extended, and preserved, even if the mine may be limited, since it cannot be known to what extent it may be enlarged, or how soon it may be abandoned.

A deep mine filled with water, of which no record is filed or plan preserved, not only depreciates the value of the property on which it exists, and all other properties in the same basin or in the vicinity, but is always a menace to all future operation in the neighborhood. We have noticed the fruits of this carelessness particularly in the Richmond (Virginia) coal-field; but its evils exist perhaps to a greater extent in the anthracite regions, where many an old half-exhausted colliery has been abandoned without leaving a note or a mark to show the extent or direction of its excavations.

Millions of tons of water accumulate in the old workings, and perhaps might never be drained by direct pumping. But other operations may be carried on in the same basin, and it can never be certainly known when and where the danger may be met. A blast may shatter the protecting barrier, and in a few minutes the whole mine and all in it may be overwhelmed and drowned. This is not a stretch of the imagination, but an occurrence that has happened, and which we have no doubt will again happen when abandoned properties are reclaimed, since there is no certain mode of providing against it.

We will give a case. A slope may be six hundred feet deep, and all the available coal extracted from boundary to boundary. This is on one side of the basin. The slope is not sunk deeper; but a dip-level or small proof-slope is sunk to the depth of 150 feet to a point near the bottom of the basin. This trial-slope is simply a narrow "heading" driven down the dip of the seam: what it developed is not known, since the mine is abandoned, engines removed, and the old workings filled with water. Years pass by, and eventually a new slope is started on the same seam, but on the opposite side of the basin. The first and second lifts are worked out, and a third lift reaches the basin; but no danger is apprehended, since the old works are not driven to the bottom of the basin, and no plans remain to point out the dip or trial-slope, and no one has any knowledge or recollection of it. The result is almost certainly fatal, since nothing but a rare chance could discover the communication. It might be cut without a moment's warning, and nothing could save the mine from instant destruction.

This is not a rare case: we have known it to happen, and we know it may happen again, since many of our old collieries are left in this condition or in an analogous one. It is fortunate, however, that most of our abandoned collieries are above water-level, and in them this danger cannot exist.

It matters little how limited and primitive the mining operations which may be carried on below water-level, all coal operators owe it to each other to preserve plans of their mines. It is the direct interest of the proprietors of coal lands to compel the

execution of plans by making such a stipulation in all leases, and it is a duty which government owes to its citizens to see that their lives are guarded against in this particular, since this neglect is as criminal as the setting of "trapguns" and "pitfalls" in the highways.

We may here, perhaps, state a proposition which seems to us as one of great importance to the mining community. The anthracite coal-fields of Pennsylvania are a monopoly to the State, and of immense value to her prosperity. They constitute a source of wealth of more value to her as a commonwealth than the ability to draw at pleasure from some foreign source, if such were possible, an amount of gold equal to the total annual value of her coal-trade: therefore, any thing that depreciates this source of wealth depreciates to the same extent her sources of income.

A *keeper of the records* of her mineral wealth is, consequently, as necessary as are her secretaries or treasurers. The duties of such an office we cannot here take time to enumerate, but they will be suggested to the mind of any observant and intelligent man.

The mining and manufacturing interests of the State are the paramount sources of her industrial and progressive wealth, and must continue to be so. In order to render them available and lasting, they must be economized. This cannot be done without some system of encouragement to their development, and protection against waste and wilful ignorance, as well as against foreign competition. A faithful record of the progress of the trade and development of our mineral wealth, and statistical returns of the same, would be not only useful and instructive to the miner, the iron-master, and oil-merchant, but would display to the wealth of the world inviting fields of enterprise. A bureau of reference would be established, where the *plans* of all our mines would be filed yearly. The ventilation of our deep mines should be displayed and compared in such a manner that errors may be detected and corrected. The experience of the world might be gathered together by the "keeper of mining and mineral records," and all that practical skill, invention, science, or art has done for others may be made available to us.

TOPOGRAPHICAL PLANS.

In order to present to the inexperienced or unprofessional a comprehensive view or impression of subterraneous workings, it is necessary to present four views of the mine and its location.

1. A topographical plan.
2. A horizontal or working plan.
3. A longitudinal or side view.
4. A transverse or end view.

The topographical plan is a surface map of the mining estate, or boundaries of the mine. It shows the extent and connections of the property with surrounding lands and with the markets, and the location of the mines. A complete topographical map should also be a geological one. In addition to the boundaries, connections, locations of hills, streams, places, mines, and roads, the outcrops of all the veins or seams should be laid down, and their dips and axes given. The outcrop may be shown by a heavy black line following the strike of the seam, and the axes by blue lines running on the apex of the saddles, or in the centres of the basin; arrows pointing towards each other denote basins, or synclinal axes, and those pointing in opposite directions denote saddles, or anticlinal axes; an arrow pointing along the line of the axis denotes its elevation or depression; the direction in which the arrows point always denotes the direction of the depression.

If the estate is extensive and extends outside of the coal measures, light shades of color may be used to divide the geological formations: for instance, the coal measures may be a dark tint, the conglomerate blue, the red shale pink, and the Vespertine, or

proto-Carboniferous, yellow, or some harmonizing color. The beds of ore may be crimson, and the roads may be fine double lines in black, with the railroads crossed.

When it is possible to do so with any correctness, it is important that transverse longitudinal and vertical sections should be constructed on the margins of the map. In fact, an engineer is not capable of correctly locating a shaft or mine until such sections can be constructed at least approximately. The general dip of the strata and a few trial-pits should always enable the engineer of mines to comprehend the *axes*, *dips*, and *strikes* of the seams or lodes; for this applies as truly to ores as to coal. We have given on our map of the anthracite coal-fields sections of this character, which, however, are given more for the purpose of conveying an approximate idea of the general form and connection of our coal-fields than for local information. No geological survey or general location of axes of formation can be depended on for local operations. Each property or mining estate should be closely and carefully examined and surveyed, and the exact location of outcrops, axis, and dips laid down, before any attempt is made to develop the property; otherwise, errors which may be irreparable are always imminent.

When a mine is located, it is always done after a certain amount of inspection, and on the judgment of a practical mining superintendent. But, with the best judgment, this is a hap-hazard mode of proceeding. If the same judgment was made use of after a thorough examination and survey, with the location of the chief points on the map before it, there would be more certainty than *guess-work*, and in nine cases out of ten there would be good results. A mathematical and geometrical demonstration is proof to the practical judgment, and the mind may be easy under the responsibility of the vast expenditure attending the development of deep mines, which cannot be the case when it is all ventured on a *guess:* therefore, if $50,000 or $100,000 is not saved by a little judicious preliminary examination, much peace of mind and satisfaction certainly may be the result.

We do not say, however, that *any* surveyor or engineer may make such an examination and come to a satisfactory conclusion. It would be better to trust to the practical judgment of some experienced party than to depend on the investigations of an irresponsible engineer. But we do say that even such a survey may be useful and instructive to the experienced mining superintendent if done under his instruction and eye. It would be far better, however, if the mining superintendent were capable of doing the work himself; and we think any intelligent man, capable of so responsible a situation, may so prepare himself with reasonable application.

HORIZONTAL OR WORKING PLAN.

This is the mining plan and guide, and whoever attempts to conduct an extensive mining operation without such a guide, or working plan, does injustice to himself or his employer.

This plan gives a "bird's-eye view" of the under-ground excavations, or such as could be seen in reality if the ground were removed from above the mine, or if it were transparent and we could behold the numerous avenues and workings in the subterranean excavations. It portrays, on a miniature scale, all the gangways, headings, air-courses, tunnels, breasts, inclines, &c. &c., with the solid coal in advance, and the *goaf*, or excavated portions, in the abandoned parts of the mine.

But in this horizontal view we only see the top or mouth of the shaft, which is represented on the paper as the area of the diameter. It gives no idea of the perpendicular height or depth of shafts, slopes, inclines, or breasts. This can be obtained only from the transverse section. Nor would it represent the dip or underlay of the seam, which is also shown by the transverse section.

These plans are always drawn to a scale,—say from 20 to 100 feet to the inch; per-

haps from 30 to 50 feet to the inch may be the best scales for mining plans. If regular scaled drawing-paper is not used, it is well to draw faint lines, two inches apart, at right angles across the paper, from north to south and from east to west. These are to remain and act as cardinal points, and serve as a base for protraction without bringing up north and south lines for that purpose. They also serve to indicate the course of levels, and act as proof of the surveys, as well as a guide to the plotter.

This plan, well constructed and *proved*, becomes invaluable to the manager. He has before him a complete miniature of the mine, and can tell at once where a tunnel may be driven, a slope put up to meet a descending one, a shaft started from the bottom or the top, and the best mode of drainage, ventilation, and general working is suggested or presented. He is not liable to get the mine in disorder or confusion by increasing or decreasing dips, and consequent changes in the strike of the seam, and course of the workings of the mine.

LONGITUDINAL PLAN.

This view is not a very important one in general coal-mining operations, except in cases of steep dips and extensive workings. It presents a side view of the mine, and gives the perpendicular height and positions of shafts, gangways, air-courses, and counter-levels, but conveys no good impression of inclines, breasts, or slopes, more than may be given in the horizontal plan; yet no mining plan of pitching seams or lodes is complete without this view to the inspection of the inexperienced. It may not be necessary to the professional, yet it is almost impossible to convey a proper and clear impression of the plans and intentions of the mining superintendent to those who are not *au fait*, without the aid of this view of the mine.

TRANSVERSE PLAN.

This view of mining operations in works on pitching seams is as important as the longitudinal plan, if constructed for the purpose of conveying general information to those interested, as well as a guide to the management.

This is an end view of the works, and, if taken at a single point, represents but a limited portion of the under-ground operations. In the case of a shaft on a flat seam, we get the perpendicular height of the shaft, the point of intersection with the coal-seam, the extent to left and right of the seam, and the course of the chambers and avenues radiating from the main levels or gangways. It also shows an end view of the parallel gangways, air-courses, and headings.

In a pitching seam it gives the dip of the coal, and the size and dip of the slope, with the location of gangways, air-courses, counter-levels, and water-drains. This view, therefore, represents only one point on the longitudinal plan, or a cross-section of the horizontal plan, on a given line. If the dip is uniform, and the plan of the works general in their style, a single view is sufficient to convey a good impression of the whole; but, if the dip varies and the plan of operation changes, it is necessary that transverse sections be taken at each point where those changes are in their maximum condition.

The horizontal plan must be constructed from the notes of the survey, or from the engineer's book; but the longitudinal and transverse sections may be made in the office, by the aid of instruments and computation.

No work of this kind is of much service if it is not correct, since the nice calculations that sometimes become necessary in mining operations, for starting shafts, slopes, or air-courses at both ends,—that is, above and below,—require the survey to be proved as it progresses, by fore and back sights; and when upper and lower levels are surveyed or run, every point of intersection, where the course of the cross-cut or incline can

be obtained, should be marked, since they tend to confirm the distances if not the bearings. If the survey is made by double sights, or fore and aft dialling, it is plain that the two final sums of the traverse will demonstrate the agreement or the difference. When satisfied of the correctness of the survey, it is carefully protracted on the plan; and, to prove that the work has been properly done, we apply the computation of the dialling; say we had 807 feet of westings and 208 feet of southings, we apply these numbers to the plan by scale, and, by the aid of the cross-lines or cardinal points, prove whether the latitude and longitude of the levels surveyed or laid on the plan conform to these lines.

MINE SURVEYING.

In the following instructions on mine surveying we confine ourselves to such rules and examples as apply to coal-mining in particular, but which may, nevertheless, be used in all mining operations. The simple change of name from *seam* to *lode*, or from *gangway* to *level*, in the phraseology, is about all the difference. In fact, most of our examples are from Budge's Practical Miner's Guide, which was written principally for the Cornish copper and tin miners. We have simply changed the phraseology in some cases to adapt the rules to coal-mining.

We think the tables, rules, and examples given will be found to cover all the requirements of mining superintendents. When difficult and delicate surveys on important occasions are demanded, a professional engineer of mines may be consulted; but there are few cases in mining experience which the simple rules and examples we give will not embrace.

In order to form good and careful habits, and make correct surveys, some uniform system should be followed and strictly persisted in. We do not wish to prescribe an unalterable form or order in commencing and conducting a survey, but give what we consider a good one: those who find better systems may use them; but we would recommend earnestly that they should not be liable to lead to error, or be open to mistakes and confusion.

In conducting under-ground surveys, when they are intricate, and embrace numerous tunnels, cross-cuts, inclines, or diverging levels, it is important that these should not become confused with the main traverse. If those branches are surveyed as the main line advances, they should always be numbered as distinct lines, and if noted in the order in which they occur, should always be carefully marked and numbered, so that not only the writer, but any other practical man may read and understand them.

We may also recommend all new beginners—and perhaps the rule applies to the professional also—to let the sight or vane fixed at 360° always take the lead, and the surveyor's eye placed at the opposite vane, or end of the compass or theodolite, except when taking back observations. The remarks in connection with the converting table on page 495 will explain this more clearly.

In horizontal surveying, let two drafts be made from every station, which will expedite the work, as the surveyor will only have to wait for the settling of the needle once, instead of twice by the other method.

SURVEYING WITHOUT THE MAGNETIC NEEDLE.

This is a comparatively new method of mine surveying. "Necessity is the mother of invention," and the introduction of railroads and "tram-ways" in mines drove the surveyor to seek some substitute for the needle,—which the attraction of the iron rendered useless,—and he has succeeded.

In some mines the presence of iron ores also attracts the needle, while, generally, no correct survey can be made under ground in our coal-mines without the circumferentor or vernier scale on the outside of the compass or theodolite.

The method of surveying on this principle differs from the magnetic method chiefly in one particular, namely, that in every fresh draft the position of the bearing must be ascertained by the back observation in the direction of the sights, and the angle made at the old station must be obtained and preserved at the new station; and this is evident, because we have no magnet for our guide. For example:—Suppose we are surveying over a railway in a level, and the last observation was 259°; after measuring the length, the instrument is removed and carried forward to the place of the light where the angle was taken, and a mark and light left at the old station. Then, after the instrument has been adjusted in its true place, the next act of the surveyor is to place the centre of the vernier on 259°, as it stood at the old station; and, if the instrument does not move by rack-work, he must keep all firm with his hands, and turn the head toward the last station until the candle is seen through the sights. He then removes behind the instrument, and moves the sights in the direction for the next draft, where the assistant is holding a light for the purpose (the graduation being fixed), and this new draft gives (say) 270½°, showing a difference between the two drafts of 11½°. Although this process is somewhat tedious in description, it is simple in practice, and the history of one draft is as well as a hundred; and we may observe that, with proper care and judgment, this is the most perfect method of surveying, because there is no risk of attraction; and, as the circle is much larger than the inside plate, and the divisions more distinct, together with the vernier scale being applied, the angle can be read off to one or two minutes,—a nicety which cannot be attained by the needle in the common way. It is hardly necessary to state that, in order to obtain the bearing, there must be at least one draft in the traverse where the *needle must be brought into play*, and this draft will determine the polarity or direction of the whole.

Further, let it be remarked that a survey may be resolved into bearings, and worked trigonometrically, when this method is used, as by the needle.

Suppose a case that we are about to survey over a railway, but there is space enough clear of iron for the first draft; and, taking the observation with the needle, we find the north point (a right-hand compass) stand at 176½°; we then fix the outer circle with the vernier precisely at the same point, and then, throwing off the needle, perform all the remainder of the traverse by means of the outer circle. Hence it will be evident, then, if the outward circle is also graduated towards the right hand, that the whole course will come under the immediate operation of the "converting table," as if the work had been performed with the needle; and if the graduation should be reversed, the "left-hand" bearings will apply accordingly, regard being had to inversion in both cases.

This instrument is also well adapted for taking the bearing of slopes having a lift of iron pumps,—a job that has often baffled the skill and ingenuity of engineers and occasioned numerous and most serious errors.

The operation may be performed thus. Suppose we are in the first lift, and from thence to the second the slope dips 3 feet in 6 northerly. By applying the instrument at some point in the level near the slope (but far enough away to be free from attraction by the pumps), we find the bearing by the needle, to a point opposite the slope, to be due west, and the vernier on the outer rim standing at 90°. We then remove the instrument to the slope, where the light was held, and adjust the back observation as before directed, having 90° on the outer rim, and the needle thrown off as useless, because we are now close to the pumps. A light is to be carried down the slope as far as it can be seen, and, after the graduated circle has been screwed fast, the rack is applied, and the sights turned until we cut the candle in the bottom of the slope. This being done, we examine and read off the degree against the point of the vernier, which proves to be

(say) 187¾°. Now, as when the instrument stood in a due west position the outer circle stood at 90°, and in taking the bearing it stood at 187¾°, therefore, by subtracting 90° from 187¾° we find the gain to the right hand of west is 97¾°, and, the dip being northerly, the true bearing of the shaft is 7¾° east of north.

The imperative call for accuracy in cases of this kind will be seen when it is considered that the diagonal part of this slope is upwards of 240 feet, and the dip 3 feet in 6: consequently, the whole base is more than 120 feet, and an error in the bearing has the same effect on the survey as if it had been made in taking a horizontal draft of 120 feet long, and on which an error of 4° would throw the end of the line nearly 9 feet too far either to the right or left.

Should a surveyor be called to do a job of this kind, in the absence of a suitable instrument he may accomplish it in the following manner. Let him fix a cross-staff in such a position that through one pair of sights he can see the candle in the slope, and in the line of the other pair he has the compass fixed in the level, out of the way of the attraction: consequently, the light in the slope and the compass in the level are two objects forming a right angle with his cross-staff. He then requests his assistant to look at a light held immediately over the head of his cross-staff through the sights of the compass, and he finds this (say) 12° north of west; and, as the bearing of the shaft is exactly at right angles with this line, if the dip is northerly the bearing of the shaft will be 12° east of north; if southerly, 12° west of south. The best cross-staffs, or instruments for the express purpose of taking right angles, are now made of a hollow, cylindrical shape, of brass, with cuts or apertures for taking the observation; but a substitute may be used, on a pinch, by drawing two lines at right angles on a board about six inches square and an inch thick. Let these lines be cut half an inch deep with a fine saw, and then fix the board on a three-feet stand: if the lines are truly drawn and cut, this rough instrument will serve until a better one can be procured.

CONSTRUCTION.

The old method in laying down a traverse was by drawing a parallel line and removing the protractor at every draft. The evils of this practice are too glaring to require remark.

Fix your protractor and lay off as many drafts as will come within the convenient range of your parallel ruler; number them in order as they stand in your dialling-book; remove the protractor and lay off the first draft from the centre direct; then apply the protractor to the centre and No. 2, and make the parallel movement until you touch the end of the last line, or No. 1, and then draw and point off the length of No. 2, and so on through all the drafts you have pointed off from the protractor.

The advantages of laying down or pointing off a number of drafts at one fixing of the protractor, and then applying them in their true length and position, is most conspicuous; and the geometrician will testify of its superiority, both as it regards accuracy and expedition.

CONVERTING TABLE.

Remarks on the following table for converting the degrees recorded in the dialling-book of an under-ground survey into the bearings. (*See Table, page 495.*)

All practical men are aware of the difficulty, hazard, and delay that attend an attempt to obtain the bearing of every draft under-ground in a long and complicated survey. The best process is to record the degree or angle only at which the needle settles, and after the work is finished under-ground; then convert the various angles into the real bearing or true direction of each draft; and we may remark that the bear-

ings *must* be obtained if the work is to be mathematically proved. But, as it is not an easy matter to turn a long course of surveying into the bearings with an assurance of being correct, this table has been constructed for that express purpose; and its utility, simplicity, and perfection have been acknowledged by many practical men.

EXPLANATION.

All circumferentors (dial, or miner's compass) are not graduated alike. In all cases, 360° stands at the north point, and 180° at the south; but some are figured towards the right hand from the north point (which we call a "right-hand dial"), and others towards the left hand: so that a "right-hand dial" has 90° at the east point, and a "left-hand dial" has 90° at the west point. This diversity of graduation has often caused much perplexity and confusion among surveyors. The following table is contrived to suit both sorts of instruments, and is so plainly arranged and marked as to require but little explanation. It must be specially regarded that the table has been constructed upon the consideration that the eye of the surveyor has been applied to the south sight or vane standing against 180°: *this must be invariably the case.* Hence the *north sight must* always take the lead, and the young practitioner may here be told that in surveying a level and making double, or fore and back, drafts at every station, that although his eye must be placed at the *north* sight, necessarily, for the back observation, yet, as the dial has not been turned, *the needle will stand to the true degree for the record,* and no confusion or liability to error can occur.

In converting an under-ground survey, or any other, from angles into bearings, it is obviously our first object to know the graduation of the instrument by which the work has been performed; and if it has been a "right-hand dial," and the first draft was on 167°, the bearing would be 13° west of south; but if it was done by a "left-hand dial," the bearing would be 13° east of south The only thing where a liability to error at all exists in obtaining the bearings by inspection from this table, and where caution is required, *is in applying the fractions of degrees when they occur in the drafts.* On these occasions, observe that when the angle and bearing progress alike, as in all the left-hand side of the column, then the fraction must be *added* to the whole number of the bearing; but otherwise, as in the right-hand side, the fraction must be *deducted* from the whole number. Lastly, the following desirable proof may be resorted to:—*If the course has been correctly converted, the degree and bearing added together or subtracted from each other will make one of the following numbers:* 0, 90, 180, 270, 360; and this may be done almost at a glance, after the survey has been converted into bearings.

NOTE.—As before stated, we are quoting Budge freely in this chapter on Mine Surveying.

TABLE FOR CONVERTING ANGLES INTO BEARINGS.

Rt. Hd. Dial W. of N. Lt. Hd. Dial E. of N.		Rt. Hd. Dial N. of W. Lt. Hd. Dial N. of E.		Rt. Hd. Dial S. of W. Lt. Hd. Dial S. of E.		Rt. Hd. Dial W. of S. Lt. Hd. Dial E. of S.		Rt. Hd. Dial E. of S. Lt. Hd. Dial W. of S.		Rt. Hd. Dial S. of E. Lt. Hd. Dial S. of W.		Rt. Hd. Dial N. of E. Lt. Hd. Dial N. of W.		Rt. Hd. Dial E. of N. Lt. Hd. Dial W. of N.	
Angle.	Bearing.	Angle.	Bearing.	Angle.	Bearing.	Angle.	Bearing.	Angle.	Bearing.	Angle.	Bearing.	Angle.	Bearing.	Angle.	Bearing.
1 is	1	46 is	44	91 is	1	136 is	44	181 is	1	226 is	44	271 is	1	316	44
2	2	47	43	92	2	137	43	182	2	227	43	272	2	317	43
3	3	48	42	93	3	138	42	183	3	228	42	273	3	318	42
4	4	49	41	94	4	139	41	184	4	229	41	274	4	319	41
5	5	50	40	95	5	140	40	185	5	230	40	275	5	320	40
6	6	51	39	96	6	141	39	186	6	231	39	276	6	321	39
7	7	52	38	97	7	142	38	187	7	232	38	277	7	322	38
8	8	53	37	98	8	143	37	188	8	233	37	278	8	323	37
9	9	54	36	99	9	144	36	189	9	234	36	279	9	324	36
10	10	55	35	100	10	145	35	190	10	235	35	280	10	325	35
11	11	56	34	101	11	146	34	191	11	236	34	281	11	326	34
12	12	57	33	102	12	147	33	192	12	237	33	282	12	327	33
13	13	58	32	103	13	148	32	193	13	238	32	283	13	328	32
14	14	59	31	104	14	149	31	194	14	239	31	284	14	329	31
15	15	60	30	105	15	150	30	195	15	240	30	285	15	330	30
16	16	61	29	106	16	151	29	196	16	241	29	286	16	331	29
17	17	62	28	107	17	152	28	197	17	242	28	287	17	332	28
18	18	63	27	108	18	153	27	198	18	243	27	288	18	333	27
19	19	64	26	109	19	154	26	199	19	244	26	289	19	334	26
20	20	65	25	110	20	155	25	200	20	245	25	290	20	335	25
21	21	66	24	111	21	156	24	201	21	246	24	291	21	336	24
22	22	67	23	112	22	157	23	202	22	247	23	292	22	337	23
23	23	68	22	113	23	158	22	203	23	248	22	293	23	338	22
24	24	69	21	114	24	159	21	204	24	249	21	294	24	339	21
25	25	70	20	115	25	160	20	205	25	250	20	295	25	340	20
26	26	71	19	116	26	161	19	206	26	251	19	296	26	341	19
27	27	72	18	117	27	162	18	207	27	252	18	297	27	342	18
28	28	73	17	118	28	163	17	208	28	253	17	298	28	343	17
29	29	74	16	119	29	164	16	209	29	254	16	299	29	344	16
30	30	75	15	120	30	165	15	210	30	255	15	300	30	345	15
31	31	76	14	121	31	166	14	211	31	256	14	301	31	346	14
32	32	77	13	122	32	167	13	212	32	257	13	302	32	347	13
33	33	78	12	123	33	168	12	213	33	258	12	303	33	348	12
34	34	79	11	124	34	169	11	214	34	259	11	304	34	349	11
35	35	80	10	125	35	170	10	215	35	260	10	305	35	350	10
36	36	81	9	126	36	171	9	216	36	261	9	306	36	351	9
37	37	82	8	127	37	172	8	217	37	262	8	307	37	352	8
38	38	83	7	128	38	173	7	218	38	263	7	308	38	353	7
39	39	84	6	129	39	174	6	219	39	264	6	309	39	354	6
40	40	85	5	130	40	175	5	220	40	265	5	310	40	355	5
41	41	86	4	131	41	176	4	221	41	266	4	311	41	356	4
42	42	87	3	132	42	177	3	222	42	267	3	312	42	357	3
43	43	88	2	133	43	178	2	223	43	268	2	313	43	358	2
44	44	89	1	134	44	179	1	224	44	269	1	314	44	359	1
45	45	90	R. H. D. W. / Lt. H. D. E.	135	45	180 South.		225	45	270	R. H. D. E. / Lt. H. D. W.	315	45	360 North.	

FIRST TABLE.

HYPOTHENUSE RADIUS,

ONE FATHOM, SIX FEET.

Angle.		Base.			Perpendicular.				
Deg.	Min.	Feet.	Inches.	Decimals.	Feet.	Inches.	Decimals.	Deg.	Min.
	1	0	0	.02094	6	0		89	59
	2	0	0	.04189	6	0		89	58
	3	0	0	.06283	6	0		89	57
	4	0	0	.08387	6	0		89	56
	5	0	0	.10482	6	0		89	55
	6	0	0	.12576	6	0		89	54
	7	0	0	.14670	6	0		89	53
	8	0	0	.16765	6	0		89	52
	9	0	0	.18859	6	0		89	51
	10	0	0	.20943	6	0		89	50
	11	0	0	23038	6	0		89	49
	12	0	0	.25132	6	0		89	48
	13	0	0	.27225	6	0		89	47
	14	0	0	.29319	6	0		89	46
	15	0	0	.31414	5	11	.99982	89	45
	30	0	0	.62831	5	11	.99726	89	30
	45	0	0	94245	5	11	.99381	89	15
		Perpendicular.			Base.			Angle.	

Note.—This page will be found useful in particular cases for long lines where the angle is required to be very minute. It will be seen that as there is but the thousandth part of an inch difference in one fathom between the hypothenuse and perpendicular on the first 15′, or first ¼ of a degree, the introduction of the decimal at any less fraction would be useless.

Angle.		Base.			Perpendicular.				
Deg.	Min.	Feet.	Inches.	Decimals.	Feet.	Inches.	Decimals.	Deg.	Min.
1		0	1	.25657	5	11	.98903	89	
	15	0	1	.57067	5	11	.98286		45
	30	0	1	.88474	5	11	.97582		30
	45	0	2	.19877	5	11	.96664		15
2		0	2	.51276	5	11	.95614	88	
	15	0	2	.82666	5	11	.94249		45
	30	0	3	.14060	5	11	.93147		30
	45	0	3	.45442	5	11	.91703		15
3		0	3	.76819	5	11	.90132	87	
	15	0	4	.08188	5	11	.88420		45
	30	0	4	.39549	5	11	.86571		30
	45	0	4	.70902	5	11	.84584		15
		Perpendicular.			Base.			Angle.	

Angle.		Base.			Perpendicular.				
Deg.	Min.	Feet.	Inches.	Decimals.	Feet.	Inches.	Decimals.	Deg.	Min.
4		0	5	.02246	5	11	.82461	86	
	15	0	5	.33581	5	11	.80201		45
	30	0	5	.64905	5	11	.77805		30
	45	0	5	.96219	5	11	.75272		15
5		0	6	.27521	5	11	.72602	85	
	15	0	6	.58811	5	11	.69798		45
	30	0	6	.90090	5	11	.66853		30
	45	0	7	.21354	5	11	.63773		15
6		0	7	.52605	5	11	.60558	84	
	15	0	7	.83842	5	11	.57205		45
	30	0	8	.15063	5	11	.53718		30
	45	0	8	.46269	5	11	.50093		15
7		0	8	.77459	5	11	.46333	83	
	15	0	9	.08633	5	11	.42435		45
	30	0	9	.39789	5	11	.38403		30
	45	0	9	.70926	5	11	.34234		15
8		0	10	.02046	5	11	.29930	82	
	15	0	10	.33147	5	11	.25490		45
	30	0	10	.64228	5	11	.20914		30
	45	0	10	.95283	5	11	.16203		15
9		0	11	.26328	5	11	.11356	81	
	15	0	11	.57347	5	11	.06374		45
	30	0	11	.88343	5	11	.01256		30
	45	1	0	.19316	5	10	.96004		15
10		1	0	.50267	5	10	.90616	80	
	15	1	0	.81193	5	10	.85093		45
	30	1	1	.12096	5	10	.79435		30
	45	1	1	.42973	5	10	.73643		15
11		1	1	.73825	5	10	.67716	79	
	15	1	2	.04650	5	10	.61654		45
	30	1	2	.35449	5	10	.55458		30
	45	1	2	.66221	5	10	.49123		15
12		1	2	.96964	5	10	.42663	78	
	15	1	3	.27680	5	10	.36062		45
	30	1	3	.58365	5	10	.29331		30
	45	1	3	.89021	5	10	.22464		15
13		1	4	.19648	5	10	.15465	77	
	15	1	4	.50243	5	10	.08331		45
	30	1	4	.80807	5	10	.01062		30
	45	1	5	.11338	5	9	.93663		15
14		1	5	.41838	5	9	.86129	76	
	15	1	5	.72204	5	9	.72304		45
	30	1	6	.02736	5	9	.70663		30
	45	1	6	.33134	5	9	.62730		15
15		1	6	.63497	5	9	.54666	75	
	15	1	6	.93825	5	9	.46469		45
	30	1	7	.24116	5	9	.38139		30
	45	1	7	.54371	5	9	.29677		15
16		1	7	.84589	5	9	.21084	74	
	15	1	8	.14769	5	9	.12359		45
	30	1	8	.44910	5	9	.03502		30
	45	1	8	.75014	5	8	.94514		15
17		1	9	.05076	5	8	.85396	73	
	15	1	9	.35099	5	8	.76143		45
	30	1	9	.65082	5	8	.66762		30
	45	1	9	.95023	5	8	.57250		15
Perpendicular.					Base.			Angle.	

SECOND TABLE.

PERPENDICULAR RADIUS,

ONE FATHOM, SIX FEET.

Angle.		Base.				Hypothenuse.			
Deg.	Min.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
1		0	0	1	.2568	1	0	0	.0108
	15	0	0	1	.5710	1	0	0	.0171
	30	0	0	1	.8854	1	0	0	.0247
	45	0	0	2	.1998	1	0	0	.0335
2		0	0	2	.5143	1	0	0	.0432
	15	0	0	2	.8289	1	0	0	.0554
	30	0	0	3	.1435	1	0	0	.0684
	45	0	0	3	.4582	1	0	0	.0828
3		0	0	3	.7728	1	0	0	.0986
	15	0	0	4	.0882	1	0	0	.1159
	30	0	0	4	.4035	1	0	0	.1346
	45	0	0	4	.7189	1	0	0	.1544
4		0	0	5	.0328	1	0	0	.1757
	15	0	0	5	.3496	1	0	0	.1980
	30	0	0	5	.6664	1	0	0	.2171
	45	0	0	5	.9825	1	0	0	.2484
5		0	0	6	.2993	1	0	0	.2736
	15	0	0	6	.6158	1	0	0	.3024
	30	0	0	6	.9336	1	0	0	.3312
	45	0	0	7	.2497	1	0	0	.3636
6		0	0	7	.5672	1	0	0	.3960
	15	0	0	7	.8841	1	0	0	.4298
	30	0	0	8	.2008	1	0	0	.4658
	45	0	0	8	.5212	1	0	0	.5026
7		0	0	8	.8402	1	0	0	.5400
	15	0	0	9	.1584	1	0	0	.5803
	30	0	0	9	.4788	1	0	0	.6192
	45	0	0	9	.7992	1	0	0	.6624
8		0	0	10	.1189	1	0	0	.7056
	15	0	0	10	.4398	1	0	0	.7531
	30	0	0	10	.7604	1	0	0	.7992
	45	0	0	11	.0808	1	0	0	.8474
9		0	0	11	.4034	1	0	0	.8971
	15	0	0	11	.7259	1	0	0	.9482
	30	0	1	0	.0485	1	0	1	.0008
	45	0	1	0	.3696	1	0	1	.0548
10		0	1	0	.6936	1	0	1	.1088
	15	0	1	1	.0176	1	0	1	.1664
	30	0	1	1	.3416	1	0	1	.2262
	45	0	1	1	.6692	1	0	1	.2859
11		0	1	1	.9954	1	0	1	.3476
	15	0	1	2	.3215	1	0	1	.4106
	30	0	1	2	.6484	1	0	1	.4750
	45	0	1	2	.9760	1	0	1	.5410
12		0	1	3	.3036	1	0	1	.6085
	15	0	1	3	.6326	1	0	1	.6775
	30	0	1	3	.9617	1	0	1	.7481
	45	0	1	4	.2914	1	0	1	.8202
13		0	1	4	.6219	1	0	1	.8939
	15	0	1	4	.9538	1	0	1	.9691
	30	0	1	5	.2857	1	0	2	.0459
	45	0	1	5	.6178	1	0	2	.1242

Angle.		Base.				Hypothenuse.			
Deg.	Min.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
14		0	1	5	.9496	1	0	2	.2042
	15	0	1	6	.2858	1	0	2	.2857
	30	0	1	6	.6192	1	0	2	.3688
	45	0	1	6	.9576	1	0	2	.4535
15		0	1	7	.2888	1	0	2	.5399
	15	0	1	7	.6294	1	0	2	.6388
	30	0	1	7	.9670	1	0	2	.7174
	45	0	1	8	.3062	1	0	2	.8087
16		0	1	8	.6456	1	0	2	.9015
	15	0	1	8	.9858	1	0	2	.9961
	30	0	1	9	.3271	1	0	3	.0443
	45	0	1	9	.6695	1	0	3	.1902
17		0	1	10	.0126	1	0	3	.2898
	15	0	1	10	.3560	1	0	3	.3911
	30	0	1	10	.7008	1	0	3	.4941
	45	0	1	11	.0472	1	0	3	.5988
18		0	1	11	.3942	1	0	3	.7058
	15	0	1	11	.6220	1	0	3	.8135
	30	0	2	0	.0905	1	0	3	.9234
	45	0	2	0	.4204	1	0	4	.0352
19		0	2	0	.7916	1	0	4	.1487
	15	0	2	1	.1435	1	0	4	.2640
	30	0	2	1	.4965	1	0	4	.3811
	45	0	2	1	.8506	1	0	4	.5000
20		0	2	2	.2058	1	0	4	.6208
	15	0	2	2	.5622	1	0	4	.7434
	30	0	2	2	.9197	1	0	4	.8679
	45	0	2	3	.2783	1	0	4	.9942
21		0	2	3	.6262	1	0	5	.1224
	15	0	2	3	.9998	1	0	5	.2526
	30	0	2	4	.3615	1	0	5	.3846
	45	0	2	4	.7251	1	0	5	.5186
22		0	2	5	.0899	1	0	5	.6545
	15	0	2	5	.4560	1	0	5	.7924
	30	0	2	5	.8284	1	0	5	.9328
	45	0	2	6	.1921	1	0	6	.0741
23		0	2	6	.5622	1	0	6	.2179
	15	0	2	6	.9336	1	0	6	.3638
	30	0	2	7	.3065	1	0	6	.5117
	45	0	2	7	.6807	1	0	6	.6617
24		0	2	8	.0565	1	0	6	.8138
	15	0	2	8	.4336	1	0	6	.9679
	30	0	2	8	.8123	1	0	7	.1242
	45	0	2	9	.1924	1	0	7	.2826
25		0	2	9	.5741	1	0	7	.4432
	15	0	2	9	.9574	1	0	7	.6059
	30	0	2	10	.3422	1	0	7	.7708
	45	0	2	10	.7287	1	0	7	.9880
26		0	2	11	.1167	1	0	8	.1078
	15	0	2	11	.5065	1	0	8	.2789
	30	0	2	11	.8979	1	0	8	.4528
	45	0	3	0	.2910	1	0	8	.6290
27		0	3	0	.6858	1	0	8	.8075
	15	0	3	1	.0824	1	0	8	.9888
	30	0	3	1	.4808	1	0	9	.1714
	45	0	3	1	.8810	1	0	9	.3571
28		0	3	2	.2831	1	0	9	.5450
	15	0	3	2	.6870	1	0	9	.7354
	30	0	3	3	.0928	1	0	9	.9288
	45	0	3	3	.5005	1	0	10	.1282

Angle.		Base.				Hypothenuse.			
Deg.	Min.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
29		0	3	3	.9102	1	0	10	.3212
	15	0	3	4	.3219	1	0	10	.5220
	30	0	3	4	.7356	1	0	10	.7251
	45	0	3	5	.1514	1	0	10	.9303
30		0	3	5	.5692	1	0	11	.1384
	15	0	3	5	.9892	1	0	11	.3494
	30	0	3	6	.4112	1	0	11	.5625
	45	0	3	6	.8355	1	0	11	.7788
31		0	3	7	.2620	1	0	11	.9976
	15	0	3	7	.6907	1	1	0	.2192
	30	0	3	8	.1216	1	1	0	.4436
	45	0	3	8	.5550	1	1	0	.7008
32		0	3	8	.9906	1	1	0	.9008
	15	0	3	9	.4286	1	1	1	.1338
	30	0	3	9	.8691	1	1	1	.3696
	45	0	3	10	.3119	1	1	1	.6084
33		0	3	10	.7573	1	1	1	.8501
	15	0	3	11	.2053	1	1	2	.0949
	30	0	3	11	.6558	1	1	2	.3427
	45	0	4	0	.1088	1	1	2	.5937
34		0	4	0	.5646	1	1	2	.8477
	15	0	4	0	.9981	1	1	3	.1049
	30	0	4	1	.4842	1	1	3	.3653
	45	0	4	1	.9482	1	1	3	.6289
35		0	4	2	.4149	1	1	3	.8958
	15	0	4	2	.8846	1	1	4	.1660
	30	0	4	3	.3571	1	1	4	.4395
	45	0	4	3	.8326	1	1	4	.7165
36		0	4	4	.3111	1	1	4	.9969
	15	0	4	4	.7914	1	1	5	.2808
	30	0	4	5	.2772	1	1	5	.6819
	45	0	4	5	.5650	1	1	5	.8591
37		0	4	6	.2559	1	1	6	.1538
	15	0	4	6	.7501	1	1	6	.4520
	30	0	4	7	.2475	1	1	6	.7540
	45	0	4	7	.7483	1	1	7	.0597
38		0	4	8	.2526	1	1	7	.3693
	15	0	4	8	.7602	1	1	7	.6831
	30	0	4	9	.2884	1	1	8	.0000
	45	0	4	9	.7861	1	1	8	.3214
39		0	4	10	.3044	1	1	8	.6467
	15	0	4	10	.8265	1	1	8	.9761
	30	0	4	11	.3522	1	1	9	.3096
	45	0	4	11	.8818	1	1	9	.6473
40		0	5	0	.4152	1	1	9	.9893
	15	0	5	0	.9525	1	1	10	.0956
	30	0	5	1	.4938	1	1	10	.6863
	45	0	5	2	.0392	1	1	11	.0413
41		0	5	2	.5886	1	1	11	.4009
	15	0	5	3	.1420	1	1	11	.7651
	30	0	5	3	.7002	1	2	0	.1338
	45	0	5	4	.2624	1	2	0	.5049
42		0	5	4	.8291	1	2	0	.8855
	15	0	5	5	.4002	1	2	1	.2686
	30	0	5	5	.9758	1	2	1	.6566
	45	0	5	6	.5705	1	2	2	.0496
43		0	5	7	.1411	1	2	2	.4476
	15	0	5	7	.7308	1	2	2	.8507
	30	0	5	8	.3254	1	2	3	.2591
	45	0	5	8	.9250	1	2	3	.6727

Angle.		Base.				Hypothenuse.			
Deg.	Min.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
44		0	5	9	.5296	1	2	4	.0918
	15	0	5	10	.1398	1	2	4	.5163
	30	0	5	10	.7542	1	2	4	.9463
	45	0	5	11	.3744	1	2	5	.3820
45		1	0	0	.0000	1	2	5	.8284
	15	1	0	0	.6311	1	2	6	.2706
	30	1	0	1	.2677	1	2	6	.7287
	45	1	0	1	.9101	1	2	7	.1828
46		1	0	2	.5852	1	2	7	.6481
	15	1	0	3	.2122	1	2	8	.1195
	30	1	0	3	.8722	1	2	8	.5978
	45	1	0	4	.5382	1	2	9	.0814
47		1	0	5	.2105	1	2	9	.5721
	15	1	0	5	.8892	1	2	10	.0694
	30	1	0	6	.5742	1	2	10	.5735
	45	1	0	7	.2658	1	2	11	.0844
48		1	0	7	.9641	1	2	11	·6028
	15	1	0	8	.6692	1	3	0	.1278
	30	1	0	9	.3812	1	3	0	.6596
	45	1	0	10	.1003	1	3	1	.1991
49		1	0	10	.8265	1	3	1	.7462
	15	1	0	11	.5601	1	3	2	.3009
	30	1	1	0	.3012	1	3	2	.8634
	45	1	1	1	.0498	1	3	3	.4337
50		1	1	1	.8062	1	3	4	.0122
	15	1	1	2	.5699	1	3	4	.5987
	30	1	1	3	.3430	1	3	5	.1936
	45	1	1	4	.1236	1	3	5	.7970
51		1	1	4	.9126	1	3	6	.4091
	15	1	1	5	.7101	1	3	7	.0300
	30	1	1	6	.5164	1	3	7	.6599
	45	1	1	7	.3316	1	3	8	.2990
52		1	1	8	.1560	1	3	8	.9474
	15	1	1	8	.9898	1	3	9	.6053
	30	1	1	9	.8322	1	3	10	.2729
	45	1	1	10	.6848	1	3	10	.9505
53		1	1	11	.5472	1	3	11	.6381
	15	1	2	0	.4197	1	4	0	.3360
	30	1	2	1	.3024	1	4	1	.0445
	45	1	2	2	.1956	1	4	1	.7636
54		1	2	3	.0995	1	4	2	.4937
	15	1	2	4	.0143	1	4	3	.2350
	30	1	2	4	.9403	1	4	3	.9876
	45	1	2	5	.8776	1	4	4	.7520
55		1	2	6	.8267	1	4	5	.5282
	15	1	2	7	·7876	1	4	6	.3165
	30	1	2	8	.7606	1	4	7	.1172
	45	1	2	9	.7458	1	4	7	.9306
56		1	2	10	.7444	1	4	8	.7570
	15	1	2	11	.7556	1	4	9	.5966
	30	1	3	0	.7801	1	4	10	.4497
	45	1	3	1	.8182	1	4	11	.3165
57		1	3	2	.8703	1	5	0	.1976
	15	1	3	3	.9365	1	5	1	.0932
	30	1	3	5	.0174	1	5	2	.0034
	45	1	3	6	.1131	1	5	2	.9287
58		1	3	7	.2241	1	5	3	.8697
	15	1	3	8	.3507	1	5	4	.8265
	30	1	3	9	.4933	1	5	5	.7994
	45	1	3	10	.6523	1	5	6	.7890

Angle.		Base.				Hypothenuse.			
Deg.	Min.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
29		0	3	3	.9102	1	0	10	.8212
	15	0	3	4	.8219	1	0	10	.5220
	30	0	3	4	.7856	1	0	10	.7251
	45	0	3	5	.1514	1	0	10	.9808
30		0	3	5	.5692	1	0	11	.1884
	15	0	3	5	.9892	1	0	11	.8494
	30	0	3	6	.4112	1	0	11	.5625
	45	0	3	6	.8355	1	0	11	.7788
31		0	3	7	.2620	1	0	11	.9976
	15	0	3	7	.6907	1	1	0	.2192
	30	0	3	8	.1216	1	1	0	.4486
	45	0	3	8	.5550	1	1	0	.7008
32		0	3	8	.9906	1	1	0	.9008
	15	0	3	9	.4286	1	1	1	.1888
	30	0	3	9	.8691	1	1	1	.3696
	45	0	3	10	.3119	1	1	1	.6084
33		0	3	10	.7578	1	1	1	.8501
	15	0	3	11	.2058	1	1	2	.0949
	30	0	3	11	.6558	1	1	2	.8427
	45	0	4	0	.1088	1	1	2	.5937
34		0	4	0	.5646	1	1	2	.8477
	15	0	4	0	.9931	1	1	3	.1049
	30	0	4	1	.4842	1	1	3	.3653
	45	0	4	1	.9482	1	1	3	.6289
35		0	4	2	.4149	1	1	3	.8958
	15	0	4	2	.8846	1	1	4	.1660
	30	0	4	3	.3571	1	1	4	.4395
	45	0	4	3	.8326	1	1	4	.7165
36		0	4	4	.3111	1	1	4	.9969
	15	0	4	4	.7914	1	1	5	.2808
	30	0	4	5	.2772	1	1	5	.5819
	45	0	4	5	.7650	1	1	5	.8591
37		0	4	6	.2559	1	1	6	.1538
	15	0	4	6	.7501	1	1	6	.4520
	30	0	4	7	.2475	1	1	6	.7540
	45	0	4	7	.7483	1	1	7	.0597
38		0	4	8	.2526	1	1	7	.3698
	15	0	4	8	.7602	1	1	7	.6831
	30	0	4	9	.2834	1	1	8	.0000
	45	0	4	9	.7861	1	1	8	.3214
39		0	4	10	.3044	1	1	8	.6467
	15	0	4	10	.8265	1	1	8	.9761
	30	0	4	11	.3522	1	1	9	.3096
	45	0	4	11	.8818	1	1	9	.6473
40		0	5	0	.4152	1	1	9	.9893
	15	0	5	0	.9525	1	1	10	.0956
	30	0	5	1	.4938	1	1	10	.6863
	45	0	5	2	.0392	1	1	11	.0413
41		0	5	2	.5886	1	1	11	.4009
	15	0	5	3	.1420	1	1	11	.7651
	30	0	5	3	.7002	1	2	0	.1838
	45	0	5	4	.2624	1	2	0	.5049
42		0	5	4	.8291	1	2	0	.8855
	15	0	5	5	.4002	1	2	1	.2686
	30	0	5	5	.9758	1	2	1	.6566
	45	0	5	6	.5705	1	2	2	.0496
43		0	5	7	.1411	1	2	2	.4476
	15	0	5	7	.7308	1	2	2	.8507
	30	0	5	8	.3254	1	2	3	.2591
	45	0	5	8	.9250	1	2	3	.6727

Angle.		Base.				Hypothenuse.			
Deg.	Min.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
44		0	5	9	.5296	1	2	4	.0918
	15	0	5	10	.1393	1	2	4	.5163
	30	0	5	10	.7542	1	2	4	.9463
	45	0	5	11	.3744	1	2	5	.3820
45		1	0	0	.0000	1	2	5	.8234
	15	1	0	0	.6311	1	2	6	.2706
	30	1	0	1	.2677	1	2	6	.7237
	45	1	0	1	.9101	1	2	7	.1828
46		1	0	2	.5852	1	2	7	.6481
	15	1	0	3	.2122	1	2	8	.1195
	30	1	0	3	.8722	1	2	8	.5973
	45	1	0	4	.5382	1	2	9	.0814
47		1	0	5	.2105	1	2	9	.5721
	15	1	0	5	.8892	1	2	10	.0694
	30	1	0	6	.5742	1	2	10	.5735
	45	1	0	7	.2658	1	2	11	.0844
48		1	0	7	.9641	1	2	11	.6028
	15	1	0	8	.6692	1	3	0	.1273
	30	1	0	9	.3812	1	3	0	.6596
	45	1	0	10	.1003	1	3	1	.1991
49		1	0	10	.8265	1	3	1	.7462
	15	1	0	11	.5601	1	3	2	.3009
	30	1	1	0	.3012	1	3	2	.8634
	45	1	1	1	.0498	1	3	3	.4337
50		1	1	1	.8062	1	3	4	.0122
	15	1	1	2	.5699	1	3	4	.5987
	30	1	1	3	.3430	1	3	5	.1936
	45	1	1	4	.1236	1	3	5	.7970
51		1	1	4	.9126	1	3	6	.4091
	15	1	1	5	.7101	1	3	7	.0300
	30	1	1	6	.5164	1	3	7	.6599
	45	1	1	7	.3316	1	3	8	.2990
52		1	1	8	.1560	1	3	8	.9474
	15	1	1	8	.9898	1	3	9	.6053
	30	1	1	9	.8322	1	3	10	.2729
	45	1	1	10	.6848	1	3	10	.9505
53		1	1	11	.5472	1	3	11	.6381
	15	1	2	0	.4197	1	4	0	.3360
	30	1	2	1	.3024	1	4	1	.0445
	45	1	2	2	.1956	1	4	1	.7636
54		1	2	3	.0995	1	4	2	.4937
	15	1	2	4	.0143	1	4	3	.2350
	30	1	2	4	.9408	1	4	3	.9876
	45	1	2	5	.8776	1	4	4	.7520
55		1	2	6	.8267	1	4	5	.5282
	15	1	2	7	.7876	1	4	6	.3165
	30	1	2	8	.7606	1	4	7	.1172
	45	1	2	9	.7458	1	4	7	.9306
56		1	2	10	.7444	1	4	8	.7570
	15	1	2	11	.7556	1	4	9	.5966
	30	1	3	0	.7801	1	4	10	.4497
	45	1	3	1	.8182	1	4	11	.3165
57		1	3	2	.8703	1	5	0	.1976
	15	1	3	3	.9365	1	5	1	.0932
	30	1	3	5	.0174	1	5	2	.0034
	45	1	3	6	.1131	1	5	2	.9287
58		1	3	7	.2241	1	5	3	.8697
	15	1	3	8	.3507	1	5	4	.8265
	30	1	3	9	.4933	1	5	5	.7994
	45	1	3	10	.6523	1	5	6	.7890

Angle.		Base.				Hypothenuse.			
Deg.	Min.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
59		1	3	11	.7281	1	5	7	.7965
	15	1	4	1	.0211	1	5	8	.8194
	30	1	4	2	.2317	1	5	9	.8612
	45	1	[illegible]	3	.4604	1	6	10	[illegible]
60		1	4	4	.7077	2	0	0	.0000

FIG. 152.

BASE, PERPENDICULAR, AND HYPOTHENUSE RADIUS.

THIRD TABLE.

BASE RADIUS,

ONE FATHOM, SIX FEET.

Angle.	Hypothenuse.				Perpendicular.			
Degrees.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
1	57	1	9	.50554	57	1	8	.87726
2	28	3	11	.06698	28	3	9	.81022
3	19	0	7	.72726	19	0	5	.84186
4	14	2	0	.16226	14	1	9	.64795
5	11	2	10	.10734	11	2	6	.96374
6	9	3	4	.80760	9	3	1	.03424
7	8	1	2	.79665	8	0	10	.39294
8	7	1	1	.34135	7	0	8	.30662
9	6	2	4	.25663	6	1	10	.59011
10	5	4	6	.63148	5	4	0	.33229
11	5	1	5	.34070	5	0	10	.40789
12	4	4	10	.30087	4	4	2	.73337
13	4	2	8	.06963	4	1	11	.86626
14	4	0	9	.61672	4	0	0	.77622
15	3	5	2	.18664	3	4	4	.70766
16	3	3	9	.21278	3	2	11	.09384
17	3	2	6	.26186	3	1	7	.50139
18	3	1	4	.99690	3	0	5	.59321
19	3	0	5	.15185	2	5	5	.10318
20	2	5	6	.51392	2	4	5	.81837
21	2	4	8	.91082	2	3	7	.56641
22	2	4	0	.20164	2	2	10	.20626
23	2	3	4	.26994	2	2	1	.62137
24	2	2	9	.01872	2	1	5	.71465
25	2	2	2	.36651	2	0	10	.40450
26	2	1	8	.24438	2	0	3	.62187
27	2	1	2	.59363	1	5	9	.30796
28	2	0	9	.36392	1	5	3	.41231
29	2	0	4	.51190	1	4	9	.89144
30	2	0	0	.00000	1	4	4	.70766
31	1	5	7	.79549	1	3	11	.82812
32	1	5	3	.86975	1	3	7	.22408
33	1	5	0	.19765	1	3	2	.87028
34	1	4	8	.75699	1	2	10	.74439
35	1	4	5	.52817	1	2	6	.82666
36	1	4	2	.49371	1	2	3	.09950
37	1	3	11	.63809	1	1	11	.54722
38	1	3	8	.94738	1	1	8	.15579
39	1	3	6	.40913	1	1	4	.91260
40	1	3	4	.01211	1	1	1	.80626
41	1	3	1	.74622	1	0	10	.82652
42	1	2	11	.60231	1	0	7	.96410
43	1	2	9	.57201	1	0	5	.21055
44	1	2	7	.64807	1	0	2	.55818
45	1	2	5	.82338	1	0	0	.00000
46	1	2	4	.09178	0	5	9	.52959
47	1	2	2	.44758	0	5	7	.14108
48	1	2	0	.88555	0	5	4	.82909
49	1	1	11	.40094	0	5	2	.58864

Angle.	Hypothenuse.				Perpendicular.			
Degrees.	Fath.	Feet.	Inches.	Decimals.	Fath.	Feet.	Inches.	Decimals.
50	1	1	9	.98932	0	5	0	.41517
51	1	1	8	.64669	0	4	10	.30445
52	1	1	7	.86931	0	4	8	.25256
53	1	1	6	.15877	0	4	6	.25589
54	1	1	4	.99689	0	4	4	.31106
55	1	1	3	.89577	0	4	2	.41494
56	1	1	2	.84768	0	4	0	.56461
57	1	1	1	.85016	0	3	10	.75735
58	1	1	0	.90084	0	3	8	.99060
59	1	0	11	.99760	0	3	7	.26196
60	1	0	11	.13844	0	3	5	.56922

EXPLANATION OF THE DIAGRAM.

Table I.

In this scheme the hypothenuse is made radius: consequently, the other sides are the sine and cosine of the included angle.

Corollary.—Suppose one end of the line A B to remain at A while the other end B is moved round from *e* to *f*: then it is evident that the base C B will continue to increase, and the perpendicular B D to decrease, until the whole quadrant has been swept off.

At 45°, or the middle of the quadrant, the base and perpendicular are equal, and from that point to 90° the base will increase in the same ratio as the perpendicular decreased from 1° to 45°: hence the propriety of the arrangement of this table in counting the degrees backward from 45 to 90.

Table II.

Here the perpendicular is made radius: therefore the hypothenuse A C will be the secant, and the base B C the tangent, of the angle A. On this principle it is clear that as the angle increases the base and hypothenuse will continue (throughout the whole quadrant) to increase in proportion.

Table III.

In this diagram the base is made radius: therefore, by mathematical demonstration, the perpendicular A C is the co-tangent, and the hypothenuse B C the co-secant, of the angle C; and here it will be plain that as the angle C is increased the hypothenuse and perpendicular will proportionably be diminished.

EXPLANATION AND USE OF THE TABLES.

The reader will observe three distinct tables, for the obvious reason of making each side of the triangle radius.

In each case the radius, or given side, is one fathom, or six feet, being the most convenient and familiar proportion that could have been introduced.

The principal calculations include every quarter, or fifteen minutes of a degree, and extend from 1 to 89 degrees, being sufficiently extensive and minute for mining purposes (the angle of any intermediate division not being distinguished or required); and here

it must be observed that the divisions are expressed by 15, 30, and 45 minutes, which numbers represent ¼, ½, and ¾ of a degree.

The first and most essential table is that wherein the hypothenuse, or longest side, is made radius, extending nearly throughout the quadrant, and every calculation wrought out to five decimal places of an inch, hereby giving a direct answer, in exact ratio to six feet of the given side, to the ten-thousandth part of an inch.

Perhaps there may be a little difficulty at first, with persons unacquainted with mathematical order, in reading the first table. It must be remarked that from 1° to 45°, or the middle of the quadrant, the degrees and parts *are all on the left-hand side* descending, the base stands in the adjoining columns, and the perpendicular on the same line to the right; but beyond that point the degrees will be found on the *right-hand side ascending*, and then it must be specially noted that the perpendicular and base will have changed their positions, the base now standing on the right-hand and the perpendicular on the left-hand side.

In the second table the perpendicular is given, and the angles extend to 60°. One valuable mining property of this table is that it gives at sight the dip in six feet of every angle within the range of 60°, including the divisions: so that if it is required to know the dip in six feet on any degree, or quarter of a degree, between 1 and 60, it will be immediately discovered by an inspection of the base in the column adjoining the given angle in this table.

In the third and last table the base is given, and, as the application of this part of the work is not so general as the preceding, the angles have been given in degrees only: nevertheless this table is indispensable on some occasions, especially in levelling or driving adits. It will be found, like the second table, to extend from 1 to 60 degrees.

Having thus briefly stated the nature of the tables under each separate head, it only remains for us, after a few general observations, to recommend the learner to the inspection of the following examples; for we believe that one practical operation will do more towards giving him a clear understanding or comprehension of the subject than a volume written expressly thereon, confined to mere speculative description.

It may be remarked that in almost every instance the geometrical construction of the figure is introduced with the calculation, which will tend to the satisfaction of the practitioner and improvement of the beginner.

In conclusion, we would remark that the same attention must be paid in taking the angle and measuring the given line, when these tables are used, as if the operation were performed any other way.

It is a common practice in mining to take the angle of dips or slopes with the cover of the dial and a plumb-line; and in short drafts, with great care, this method may answer well enough; but when any very important work is to be performed we would strongly recommend the application of a more perfect instrument for ascertaining the angle; for it is well known that if this part of the process should not be correct, the result of the whole work must be erroneous as a matter of course; and, indeed, it is next to impossible to distinguish the minutiæ of an angle with any tolerable degree of certainty by the foregoing method. The theodolite certainly stands unrivalled for taking both horizontal and vertical angles.

It is not our design to enter into controversy on this subject. Those who imagine the sextant or quadrant graduated on the cover of the dial well calculated for the purpose, let them continue to use it; only we would especially note that, should an error ensue, it ought by all means to be attributed to the real cause, and to that only; for, as in all trigonometrical questions, the angle and side are always given to find the other parts of the triangle: consequently, the sum of the one and length of the other are presupposed to have been correctly ascertained previous to the commencement of any other operation.

Finally, for the learner's sake, we observe that, as the tables exhibit only the relative proportions to the radius of one fathom, or six feet, and are wrought out to five places of decimals to an inch, it becomes necessary that every one who would use this work successfully should have some knowledge of decimated arithmetic, because he will have, in most cases, to multiply for the whole numbers and take parts for the fraction of the fathom. For example, suppose the given side to be the hypothenuse, measuring 16 fathoms, 3 feet, and 6 inches: he will then have to take out the numbers opposite the given angle in the tables, and multiply them by 16, for the base and perpendicular respectively, then divide half the tabular measure for the 3 feet, odd feet, and one-sixth of the remainder for the 6 inches, and add them together for the sum of the required sides of the triangle.

It has been observed that the radius in every case is 6 feet, or 1 fathom: consequently, the number of fathoms in the given side, whether that side be hypothenuse, perpendicular, or base, will be the multiplier of the tabular numbers; and should there be a fraction in the multiplier, the multiplicand must be divided by that fraction, agreeably with the rule of practice.

In some of the following examples the product has been obtained in fathoms and parts; but we would recommend the learner to carry on the work in *feet* (except in cases where the answer is required in fathoms), as he will find it more simple and expeditious. We speak of the *multiplicand*, or number *multiplied*. The *multiplier* must invariably be fathoms; and should the given side be nominated in feet, it must be divided by 6, to bring it into fathoms, before the operation is begun by the foregoing cases.

It may be further noticed that when any of the given sides in the tables amount to 6 feet, they are expressed in fathoms, &c.; but whenever it may be required to produce the answer in feet, &c., the numbers should be reduced to that measure before they are multiplied, and this can be done by mere inspection, viz.:*

		Fath.	Ft.	In.			Ft.	In.
Table 2d, <52°............	Base,	1	1	8.1560	state	Base,	7	8.1560
	Hyp.	1	3	9.6058		Hyp.	9	9.6058

DEFINITION OF A RIGHT-ANGLED TRIANGLE.

In order to use the foregoing tables with due effect, there is no necessity that the reader should understand any thing of the science of trigonometry, that part of the work having been accomplished: so that, by the help of a few of the common rules of arithmetic, he may obtain, with the greatest ease and certainty, every thing required to be known in the geometrical part of mining.

Previous to an elucidation of the simple method of working by the tables, it may be satisfactory to introduce the operation by a few preliminary observations and extracts on the nature and properties of right-angled triangles.

Plane trigonometry is the art of measuring the sides and angles of triangles described on a plane surface, or of such triangles as are composed of straight lines.

The theory of triangles is the very foundation of all geometrical knowledge; for all straight-lined figures may be reduced to triangles. The angles of a triangle determine only its relative species, and are measured in degrees, minutes, and seconds; but the sides determine its absolute magnitude, and may be expressed in fathoms, yards, feet, or any other lineal measure.

* As before observed, these tables are from "Budge's Practical Mining Guide,"—a Cornish work,—in which fathoms are used generally. To convert them into feet here would only confuse, and not add to the simplicity of the operation.

THEOREMS.

A right-angled triangle (the only kind generally necessary to be treated of for mining urposes) is that which has one right angle in it. The longest side, or that opposite to ie right angle, is called the hypothenuse; the other two are called the legs or sides, or ie base and perpendicular: or, by Euclid's definition, "In a right-angled triangle, the de opposite to the right angle is called the HYPOTHENUSE; and of the other sides, that pon which the figure is supposed to stand is called the BASE, and the remaining side ie PERPENDICULAR."

The three angles of every triangle are together equal to two right angles, or 180 egrees.

The greater side of every triangle has the greater angle opposite to it.

The squares of two sides of a triangle are together double the square of half the ase, and of the square of a straight line drawn from the vertex to bisect the base.

The sum of the three angles of every plane triangle being equal to half a circle, or 80 degrees, it therefore follows that if either acute angle, in such triangle, be taken rom 90°, the remainder will be the other acute angle, or the complement.

The supplement of any angle is what that angle wants of 180°: hence the supplement of any one angle is always equal to the sum of the other two.

A few other properties of right-angled triangles may be worthy of notice, viz.: when he angle opposite the base is 30°, the hypothenuse is exactly double the length of the base.

When the angles are 45°, the base and perpendicular are equal.

When the angle opposite the base is 60°, the hypothenuse is double the length of the perpendicular.

Application.

To show how a knowledge of the foregoing theorems may be rendered useful in mining practices, suppose in the triangle A B C, figure 153, the base B A represented a drift or cross-cut, and the side A C a seam, making an angle with the base of 66° 30′: consequently, the angle A must be 23° 30′, because it requires that number of degrees to constitute a right angle, the complement of the angle A, or 180°, the supplement of the triangle A B C.

Again, suppose the angle C of the slope C A, figure 154, were found to be 39° 30′: then the opposite angle A must contain 50° 30′.

We now approach towards the actual use of the tables, and have succeeded, we hope, in clearing all impediments out of the learner's way, so that he will find no difficulty in readily applying the numbers to dialling operations. We have previously set a few examples of the mere act of taking out the primes, and have studiously endeavored to render every thing as perspicuous and comprehensible as the nature of the work would possibly admit. But should any one have gone thus far and still find an obscurity hang over him, so that he cannot penetrate into the nature of the subject as he would wish or as he may have expected, yet let him not be discouraged: this will always be the case with every one who calculates on fully comprehending any thing connected with the mathematics by definition or description only. Let him steadily, attentively, and perseveringly proceed with the examples, and, if he is properly interested in the matter, he will soon find the subject open with perspicuity and demonstration on his mind, and convey to him the incontrovertible assurance of the truth of the calculations, as well as the correctness of his own views, ideas, or conceptions of the subject.

Table I.—Example.

When the angle is 9° and the hypothenuse 1 fathom, what is the length of the other two sides of the triangle respectively?

Ans. Base, 11.26328in., Perp. 5ft. 11.11356in.

Example.

When the angle is 48° 15′, or 48¼ degrees*, and the hypothenuse 1 fathom, what are the lengths of the other sides? *Ans.* Base, 4ft. 5.71613in., Perp. 3ft. 11.94348in.

Table II.—Example.

When the angle is 35° 45′, or 35¾ degrees, and the perpendicular 1 fathom, what is the length of the hypothenuse and base respectively?

Ans. Base, 4ft. 3.8326in., Hyp. 1fath. 1ft. 4.7165in.

Example.

Given the angle 59° 30′, perpendicular 1 fathom; the other sides are required.

Ans. Base, 1fath. 4ft. 2.2317in., Hyp. 1fath. 5ft. 9.8612in.

Table III.—Example.

Given the angle 5°, base 1 fathom; the hypothenuse and perpendicular are required.

Ans. Hyp. 11fath. 2ft. 10.10734in., Perp. 11fath. 2ft. 6.96374in.

Example.

Given the angle 30°, base 1 fathom; the other sides are required.

Ans. Hyp. 2fath. 0ft. 0in., Perp. 1fath. 4ft. 4.70766in.

Note.—The foregoing examples serve only to exemplify the manner of taking out the primes from the tables; and, as the given side is exactly one fathom, of course the tables give a direct answer. In the following example the mode of taking out the tabular numbers is precisely as the foregoing, *but the number of fathoms contained in the length of the given side will be the multiplier of the other sides of the triangle.*

PLANE TRIGONOMETRY. BY THE TABLES.

Case I.—When the Hypothenuse is given.

Rule.—Look in the first table, and against the given angle stands the base and perpendicular, answering to one fathom of the hypothenuse; take out these numbers, and multiply them respectively by the length of the hypothenuse.

Example.

Given the angle 23° 30′, and hypothenuse 12 fathoms; the base and perpendicular are required.

Operation.

Base.	*Perpendicular.*
Feet 2 . 4.70993	Feet 5 . 6.02833
12	12
28 . 8.51916	66 . 0.33996

* In this example, as the angle exceeds 45°, it will be found standing on the right-hand side of the page (as already explained), and the denomination of the required sides will be found at the bottom. A little attention to this order will prevent the mistake, which may otherwise take place, by an inversion of the base and perpendicular.

By Construction.

Fig. 153.

PROCESS.

Draw the line A B of any length; make the angle C = 23° 30′ by a scale of chords, or with a protractor; draw the hypothenuse A C = 72 feet from a scale of equal parts Fr m C let fall the perpendicular C B; then A B C is the triangle required. A B, measured by the same scale of equal parts, will be 28 feet 8½ inches, and B C will be 66 feet.

CASE II.—WHEN THE PERPENDICULAR IS GIVEN.

RULE.—Look in the second table, and opposite the given angle will be found the base and hypothenuse corresponding to one fathom of the perpendicular; multiply these numbers separately by the length of the perpendicular.

EXAMPLE.

Given the angle 39° 30′, and perpendicular 9 fathoms 3 feet; the hypothenuse and base are required.

Operation.

	fath.	ft.	in.
3 | ½	0	4	11.3522
			9
	7	2	6.1698
	0	2	5.6761
Base,	7	4	11.8459*

	fath.	ft.	in.
3 | ½	1	1	9.3096
			9
	11	3	11.7864
	0	3	10.6548
Hyp.	12	1	10.4412

By Construction.

Fig. 154.

PROCESS.

Draw the line A B of a sufficient length; at any point B erect the perpendicular B C, which make equal to 57 feet by a scale of equal parts. At C make the angle = 39° 30′, the complement of A. From C draw the hypothenuse, and it will cut the base A B in the point A; then will A B measure 47 feet, and A C 73 feet 10 inches.

CASE III.—WHEN THE BASE IS GIVEN.

RULE.—Look in the third table, and opposite the given angle (as in the former cases) the corresponding numbers to one fathom of base will be seen, which, being multiplied by the given length of the base, produces the hypothenuse and perpendicular.

* It has been before observed that it would be better to bring the answer out in feet than in fathoms, as in the last case.

EXAMPLE.

Given the angle 20 degrees, and base 28 feet 9 inches; the hypothenuse and perpendicular are required.

Operation.

		ft.	in.
[illegible]	[illegible]	17	6.51392*
			4
		70	2.05568
	[illegible]	8	9.25696
	[illegible]	2	11.08565
		2	2.31424
Hyp.		84	0.71253

		ft.	in.
	[illegible]	16	5.81837*
			4
		65	11.27348
	[illegible]	8	2.90918
	[illegible]	2	8.96972
		2	0.72729
Perp.		78	11.87967

FIG. 158.

By Construction.

PROCESS.

Draw the base A B, which make = 28 feet 9 inches from a scale of equal parts; at B erect the perpendicular B C, make the angle A = 70°, and draw the hypothenuse A C to cut the perpendicular B C in the point C; then will A C measure 84 feet, and B C 78 feet 11¾ inches.

APPLICATION OF THE TABLES TO DIAGONAL SHAFTS AND SLOPES.

REMARKS.

As in the foregoing cases each side of the triangle is distinctly made radius, it follows that every problem in oblique surveying, &c. can be solved by one or the other of these cases; because in every instance a side and the angles are always given.

GENERAL RULE.

When the hypothenuse is given, work by case the first.
When the perpendicular is given, work by case the second.
When the base is given, work by case the third.

* These numbers stand in the tables in fathoms, &c.; the hypothenuse will be found 2 fathoms, 5 feet, 6 inches, &c., and the perpendicular 2 fathoms, 4 feet, 5 inches, &c.

Example 1.

A diagonal shaft or slope A B was found to measure 84 feet,* and the angle of declination observed to be 48 degrees; required the base B C, and perpendicular A C, or the depth of a shaft from the top of the slope, and a tunnel from shaft to slope.

By Case I.

Fig. 156.

	ft.	in.
< 48°	4	5.50643
		7
	31	2.54501
		2
Base	62	5.09002

	ft.	in.
	4	0.17740
		7
	28	1.24180
		[illegible]
Perp.	56	[illegible].48360

Example 2.

A perpendicular shaft B C, measuring 57 feet, was found to intersect an underlying or dipping seam A C, whose angle of acclivity was observed to be 50° 30′; required the length of the underlay or slope A C on the seam A C, and the distance from the perpendicular at the surface A B.

By Case II.

Fig. 157.

			ft.	in.
< 50° 30′ Comp. 39° 30′	Base	½	4	11.3522
				9
			44	6.1698
			2	5.6761
	A B		46	11.8459

		ft.	in.
Hyp.	½	7	9.3096
			9
		69	11.7864
		3	10.6548
A C		73	10.4412

Note.—In the above example, the angle having again been taken with the horizon, the operative angle will be 39° 30′, because 50° 30′ — 90° = 39° 30′. We may also observe that, the length of the shaft being 57 feet, the multiplier is 9½, or 9 fathoms 3 feet.

---

* When the given line is denominated in feet, it must be brought into fathoms by dividing it by 6 (the number of feet in a fathom): thus, in the above example, the shaft being 84 feet is 14 fathoms, and therefore the numbers are multiplied by 7 and 2, which are equal to 14.

Example 3.

A horizontal cross-cut or tunnel B C from the foot of a slope B A to a perpendicular shaft C A was found to measure 224 feet 8 inches, and the angle of acclivity (taken at B, the foot of the shaft) 40 degrees; I require the respective lengths of the hypothenuse A B and perpendicular A C.

Fig. 158.

By Case III.

		ft.	in.
< 40° Comp. 50°	⅓	7	9.98932*
			12
		93	11.87184
			3
		281	11.61552
		7	9.98932
	⅓	2	7.32977
		0	10.44325
A B		293	3.37786

		ft.	in.
	⅓	5	0.41517
			12
		60	4.98204
			3
		181	2.94612
		5	0.41517
	⅓	1	8.13889
		0	6.71279
A C		188	6.21247

Example 4.

When a seam has changed its underlay or dip.

Rule.—Take out the numbers opposite the given angles, and work them by the former cases; then add their sums together respectively for the answer.

Problem.

In surveying a shaft sunk on a seam, it was found that the first draft B D measured 71 feet, on an angle of 14° 45′, but from that depth to the foot of the shaft C the angle

* It will be observed that this number stands in the table 1 fathom, 1 foot, 9.98932 inches, and the angle having been taken at the foot of the shaft, the complement of that angle (i.e. what it wants of 90°) must be used: therefore the above tabular numbers will be found in the column opposite 50°, being the complement of 40°.

FIG. 159.

proved to be 40° 15′, and the length D C 54 feet; required the distance from the top of the slope B, where a perpendicular shaft ought to be sunk, in order to come down exactly at the foot of the underlay or slope; also the depth of the perpendicular A C.

OPERATION.

Base.

			fath.	ft.	in.
< 14° 45′	1	¼	0	1	6.33134
					12
			3	0	3.97608
			[illegible]	0	3.05522
			3	0	0.92086

Perpendicular.

		fath.	ft.	in.
1	¼		[illegible]	9.6273
				12
		11	3	7.5276
		0	0	11.6045
		11	2	7.9231

Base.

	fath.	ft.	in.
< 40° 15′ =	0	3	10.52093
			9
	5	4	10.68837

Perpendicular.

fath.	ft.	in.
0	4	6.95274
		9
6	5	2.57466

Summary of Bases.

	fath.	ft.	in.
	3	0	0.92086
	5	4	10.68837
	8	4	11.60923
	6		
A B	52 feet	11 in.	

Summary of Perpendiculars.

	fath.	ft.	in.
	11	2	7.9231
	6	5	2.57466
	18	1	10.49776
	6		
A C	109 feet	10 in.	

PERPENDICULAR SHAFTS AND LEVELS.

RULE.—When the angle of acclivity is given, take the complement (or what it wants of 90°) for the operative angle; in every other particular, work by the former cases.

FIG. 160.

A perpe
face of the
be driven
depth of th

C
4

An adit
hill from

the adit at B, 348 feet from the tail at A; also the depth of the shaft C B, the angle of acclivity from A towards C being 33 degrees. Or thus:—Given the base 348 feet; angle of acclivity 33°, of which the complement or angle of declivity is 57°; required the hypothenuse and perpendicular.

By Case III.

	Hypothenuse.			*Perpendicular.*	
	ft.	in.		ft.	in.
Comp. < 33° is 57° =	7	1.85016		3	10.75735
		8			8
	57	2.80128		31	2.05880
		7			7
	400	7.60896		218	2.41160
	14	3.70032		7	9.51470
A C	414	11.30928	C B	225	11.92630

HORIZONTAL DIALLING.

Rule.—Observe which side of the triangle is given, and work by the specified case. When there is more than one draft in the operation, add the sums of the respective sides together for the answer.

Example 1.

Being required to put down a shaft at B, 618 feet due east of a slope at A, I am prevented from measuring in a direct line by intervening hills and wood; I therefore find it necessary, in order to avoid these obstructions, to go on an angle of 27° south of east

Fig. 169.

from the shaft A. What distance must I proceed in this direction before I come at right angles with B, or due south of the eastern extremity of the given line, and how far must I then measure in a northerly direction to come exactly on the required spot?

Or the question may stand thus:—Given the perpendicular 618 feet, angle 27°; the hypothenuse and base are required.

OPERATION.

		Base.		*Hypothenuse.*	
		ft.	in.	ft.	in.
	27° =	3	0.6858	6	8.8075
			10		10
		30	6.8580	67	4.0750
			10		10
(Multiplier 103 fath.)		305	8.5800	673	4.7500
		9	2.0574	20	2.4225
		314	10.6374	693	7.1425

PETERSBURG MINE.

We have been kindly furnished by General Pleasants with the necessary data to present our readers with several interesting illustrations of the celebrated Petersburg Mine, and the triangulation by which the distance and direction were obtained to reach the rebel fort.

It will be noticed by diagrams Nos. 1 and 2 that the fort blown up was concealed behind the front line of rebel rifle-pits or breastworks, and from a front view no evidence

FIG. 168.

PETERSBURG MINE.

of a fort appeared, as the embrasures were concealed. But a distant end-view enabled General Pleasants to locate it, and subsequent demonstration provoked the rebels to unmask.

The sketch of the front or mouth of the mine represents a little hollow below and outside our breastworks, which are represented above covered with sand-bags. Between the mouth of the mine and the breastworks, or rifle-pits, is shown the air-shaft for the ventilation of the mine.

The timbers are represented in the sketch as they were used in the mine,—forming a frame; they were cut, notched, and fitted at a distance, and when taken into the mine were put into their place, and secured by thin wooden wedges, without creating a noise. As at the building of Solomon's temple, "the sound of a hammer was not heard."

Four pieces were used,—that is, the cap or "collar," the two "legs," and the "mud-

sill." These frames were placed about three feet apart, and when the clay or material driven through was soft and yielding, boards or "laggins" were placed behind the timbers.

The excavated material—earth, clay, &c.—was taken to the surface in cracker-boxes, as represented in the sketch.

Figure 164 represents the relative position of the Union and rebel works, the direction and form of the mine, and its lateral galleries, in which the powder was laid. The mouth of the mine is represented by 1, the air-shaft by 6, the left chamber, or lateral, by 2, and the right chamber by 3. The rebels sunk a counter-mine at 4; but General Pleasants very ingeniously "surrounded them" by describing nearly a half-circle in the right chamber.

FIG. 164.

This figure also represents the triangulation by which the distance and course were obtained to the rebel fort, as explained below.

Figure 165 represents a section or end-view of the Union and rebel works, and a longitudinal view of the mine. The mouth is in a hollow behind the Union rifle-pits

FIG. 165.

or breastworks G H, under which the mine is driven. It then crosses the intermediate space between the lines, passing the rebel rifle-pits F E, and ending under the fort D C. It is nearly horizontal for over one-third of the distance, but an incline rises near the middle to avoid a tough, hard clay, and runs to a point near the rebel rifle-pits F E, and from thence it was driven level. This elevation brought the interior of the mine only a short distance below the ditch of the fort,—perhaps less than 10 feet.

The air-shaft is represented by 6, and the rebel counter-shaft by 4. Abatis are erected before the Union and rebel works.

Explanation.

The rebel rifle-pits or breastworks are represented in figure 164 by E F; C D is the rebel fort; G H are the Union rifle-pits or breastworks; A B *the base-line of the triangulation*, and 1 2 3 the main and lateral galleries of the mine.

The base-line was accurately measured, and the angles B A C and B A D were measured by the vernier of a theodolite placed over the point A, and the angles A B C and A B D were obtained in the same manner from the point B.

Subtracting the sum of the angles C A B and A B C from 180° gives the angle A C B. In the triangle A B C we have, therefore, the side A B, and the angles, to find the length of the side A C, which was found by trigonometry thus:—As sine of A C B : sine A B C : : logarithm of A C, or the distance to the fort.

In like manner, with the same base-line, two observations were made from the points A and B to the point D on the rebel fort, and the distance B D calculated by the same formula.

By knowing the two distances A C and B D to the fort, the course of its parapet was obtained by plotting it on paper, which was necessary in order to know what courses were to be given to the lateral galleries in which the powder was placed.

As the entrance to the mine was some distance back of the base-line A B, that distance was ascertained and added to that from the base-line to the fort.

The main gallery was not driven perfectly straight, and a survey of it was found necessary. The different changes of course were noted, and the whole distance plotted on a plan which General Pleasants made of the entire work.

Some idea may be had of the difficulties and dangers attending the triangulation, when it is known that the aim of the enemy's riflemen was so accurate that no one could keep his hand raised over the breastworks two minutes without having a bullet put through it.

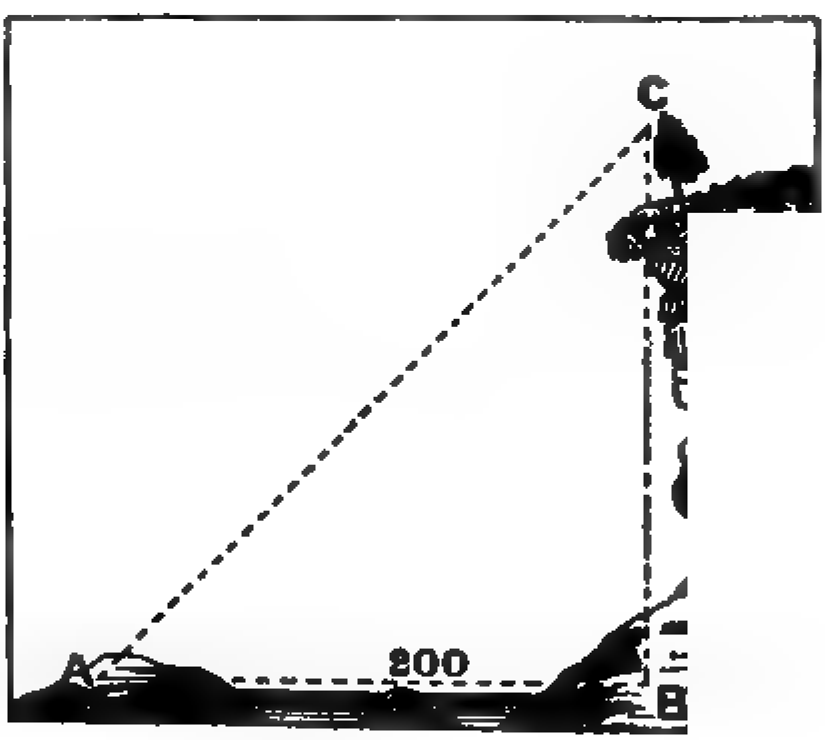
The points selected on the fort to which the triangulations were made were lumps of reddish clay, there being no staff or other well-marked object upon which the observations could be made; while the theodolite was covered with a piece of soiled cloth, so as not to attract attention, and the sights taken through holes in our front breastworks. Besides these difficulties, the galleries of the mine were too small or low to admit of the use of the instrument with its tripod, and it was found necessary to take the head of it off and place it on a cracker-box, which was levelled slowly and with great labor by placing pieces of clay beneath it.

For further information, see testimony and report of Colonel (now General) Pleasants, pages 125 to 132 of the Report of the Committee on the Conduct of the War in regard to the attack at the Petersburg Mine.

VERTICAL DIALLING, OR THE MENSURATION OF HEIGHTS.

RULE.—Observe the given side and angle, and work by the respective cases as heretofore.

FIG. 166.



Example.

From the bottom of a precipice at B, I measured 200 feet in a direct line B A on a horizontal plane; I then took the angle A 42°: required the height of the crag and tree B C.

Operation.

		ft.	in.
Complement of < A 42° is < C 48°	½	5	4.82909
			11
		59	5.11999
			3
(Multiplier 53 fath. 2 ft.)		178	3.35997
		1	9.60969
	Ans. B C	180	0.96966

In operations of this nature the hypothenuse need not be regarded.

HORIZONTAL OR TRAVERSE DIALLING.

Plane sailing in navigation, and horizontal dialling in mining, are nothing more than the practice of right-angled trigonometry, calling the hypothenuse the distance, the perpendicular the difference of latitude, the base the departure, and the angle opposite the base the course: consequently, any range of dialling, however complicated and extensive, may be reduced into a single triangle, the perpendicular of which will either be the east and west or north and south line, according to the main direction or bearing of the work; the hypothenuse will be the actual length of the dialling in a right line from the point of setting out to the termination; the base will be the distance the terminating point will fall right or left of the perpendicular; and the angle made by the hypothenuse with the perpendicular will be the final course or direction of the work.

It therefore follows that the general practice of repeating or retracing a course of underground dialling on the surface may be avoided, and thereby the difficulties and dangers arising from obstructions, irregular ground, and the attraction of the magnet by iron, which always abounds in the vicinity of a mine, be done away.

What is said of Mercator's sailing may, in the chief respect, be applied to horizontal dialling, viz.: "It is the art of finding on a plane surface the motion of a ship upon any assigned course by the compass, which shall be true in latitude, longitude, and distance sailed."

The first thing to be attended to is the statement of the work, or so placing the drafts that there may be no confusion in the operation, and that the perpendiculars and bases may fall on their proper sides.

In order to succeed in this essential matter, which may be considered the foundation of the work, note on which cardinal point the main direction of your dialling runs, whether east, west, north, or south, and reckon off your degrees right or left from that line: thus, if your dialling runs easterly or westerly, let the equator, or east and west line, be the point for numbering off your angles,—if northerly or southerly, the meridian, or north and south line: consequently, this line will be the perpendicular of every triangle in the operation that comes within the sweep of half the circle, or 180°; and should any of the drafts return beyond the north or south points, or exceed 90° right or left of the east point, then the angle must be counted from the west towards the north or south, as the draft may happen to incline.

This being done, it is evident that on a course of east and west dialling the bases

north and bases south must be subtracted one from the other, and the remainder will be the departure or base-line, north or south as the dialling may have prevailed on this or that side; and if any of the drafts have gone westerly, then the perpendiculars west must be subtracted from the perpendiculars east, for the real length of the perpendicular; but if the dialling has prevailed most in a westerly direction, the perpendicular will lie on that side: in short, as a matter of course, either for the difference of latitude, or rather difference of longitude in this case (the perpendicular), or for the departure (the base), the less number must be taken from the greater, and the differences will show the sides on which the operation lies.

This process must all be performed by the first table, where the hypothenuse is given, because in every case the actual measured line will be the longest side of the triangle; and after stating the work, as before directed, take out the numbers standing against the given angles in the table, and multiply them respectively by the length of the hypothenuse, reduced into fathoms and parts (if any), and place them in their proper positions until the whole has been calculated; then take the sum of the bases north and south one from the other, and the sum of the perpendiculars east and west one from the other; the perpendicular remainders will show the east and west line, and the bases the distance the dialling has extended north or south of that line.

The work is now brought to that case where the difference of latitude and departure is given to find the course and distance, and in order to avoid the necessity of introducing extensive and intricate tables, used by navigators for this purpose, we shall have recourse to one simple act of instrumental operation, and, as two sides of the triangle are given, the thing may be quickly and safely performed: thus, draw the base the given length by a scale of equal parts, raise the perpendicular on one end of the base (and of course at right angles therewith), and mark off the given length, draw the hypothenuse, and the triangle will be complete; then, by the same scale, measure the hypothenuse, and it will be the actual length of the dialling in a right line, from beginning to end; then, with a protractor or scale of chords, measure the angle opposite the departure or base, and it will be the true course, bearing, or direction of the extreme points.

The degrees on the miner's compass are generally graduated from 1 to 360, and are figured towards the left hand: consequently, 90° stands at the west point, 180° at south, 270° at the east, and ends with 360° at the north; and when the same course is to be pursued,—that is, when the angles are to be taken and the drafts measured again,—there will be no necessity for finding the real direction of the line; for, as the sights are always fixed, the dialler need only be careful to observe that the needle stands at the same degree as in the original course: but, when the operation is to be plotted or trigonometrically proved, there will be a necessity for ascertaining the actual bearing of every draft in the work; and this may be done by the following rule:—

RULE.

(Sights fixed North and South.)

When the needle rests on any degree.		The direction of the sights or the course of the survey will be	
	From 1 to 90 N. to W.		E. of N. Complement N. of E.
	From 90 to 180 W. to S.		S. of E. Complement E. of S.
	From 180 to 270 S. to E.		W. of S. Complement S. of W.
	From 270 to 360 E. to N.		N. of W. Complement W. of N.

APPLICATION OF THE CONVERTING TABLE.

(*See page 495.*)

Suppose the needle stood at 246½°: what is the bearing?

Ans. By a right-hand dial, 23½° S. of E. By a left-hand dial, 23½° S. of W.

It may be remarked that the table is equally applicable for changing bearings into angles if required. For example:—An observation was made with a right-hand dial, and the bearing found to be 27° 17′ E. of N.: at what degree did the needle point?

Ans. 332° 43′; and if proof is required, it will be seen that the sum of these degrees and minutes is 360°.

Example.

Convert the following angles taken with a left-hand dial into bearings:—

210¼°, 176½°, 305¾°, 28½°, 107⅛°, 97¾°.

Operation.			Proof.
210¼°	is 30¼°	W. of S.	210¼° — 30¼° = 180°
176½	3½	E. of S.	176½ + 3½ = 180
305¾	35¾	N. of W.	305¾ — 35¾ = 270
28½	28½	E. of N.	28½ — 28½ = 0
107⅛	17⅛	S. of E.	107⅛ — 17⅛ = 90
97¾	7¾	S. of E.	97¾ — 7¾ = 90
348	12	W. of N.	348 + 12 = 360

Example.

Convert the following angles taken with a right-hand dial into bearings:—

9° 45′, 239° 25′, 331° 12′, 160° 58′, 45° 6′.

Operation.			Proof.
9° 45′	is 9° 45′	W. of N.	9° 45′ — 9° 45′ = 0°
239 25	30 35	S. of E.	239 25 + 30 35 = 270
331 12	28 48	E. of N.	331 12 + 28 48 = 360
160 58	19 2	W. of S.	160 58 + 19 2 = 180
45 6	44 54	W. of N.	44 54 + 45 6 = 90

N. B.—In practice, it would not be necessary or convenient to *state* proofs: it is introduced here for the learner's sake, that he may be enabled to insure certainty in this essential matter.

In pressing on our young mining friends the advantage of adopting a perfect system, we advise that in preparing a course of dialling for trigonometrical solution, by changing the angles into bearings, care should be taken that all the drafts should be made either to exceed 45°, or that they should all stand below, or at least not exceed, that half quadrant. Our reason for being urgent on this matter is, that there may be a uniformity in placing the sides in the traverse table after the draft has been computed. And let it be particularly noticed that, if the bearings are not suffered to exceed, 45°, that the *last* expression of the bearing will signify the *longer* of the two sides. That is, suppose a draft taken under ground was 287¼°, measuring 45 feet 8 inches; now, looking at the "converting table," we see that, if this draft was taken with a "left-hand dial," the bearing is 17¼° north of west (or N. of W.), and the two sides will be found by computation to be 13 feet 7 inches, and 43 feet 7 inches. *Query*, into what columns respectively must these numbers be placed? As the bearing was north of west, and

our system states that "the last expression of the bearing will signify the longer of the two sides;" consequently the longer side (43 feet 7 inches) must be placed in the "west" column, and 13 feet 7 inches in the north column.

If this order is followed up, it will render the working of traverses (which is the most important operation in mine surveying) a plain, pleasing, and satisfactory exercise. In this edition we would needs bring forward every thing likely to promote the advancement of the young mining officer in this paramount branch of his profession, and therefore give him to understand that, in traversing, there must be a regular course from beginning to end.

We shall make ourselves understood in this matter, by taking a case where a person makes a survey for the purpose of ascertaining the length and bearing of a level driven on an east and west lode; and, for some convenient purpose, he begins his surveying at some point about the middle of the level, and surveys from thence to the eastern end; he then returns to the station or start at the middle of the level, and continues on to the western end, and thus completes the survey.

Now, if he were to proceed to work the traverse from his note-book in this state, his results would appear as if his level were almost without length or bearings, as his eastings would be balanced by his westings, &c.

In order to go *systematically* to work in this case, his first operation must be to reverse the order of one or the other of the surveys; that is, if he pleases to let the first remain, which is the eastern, and would accommodate the western part to suit the other, he must alter or reverse all the drafts, by converting (say) 16° south of west into 16° north of east, and so of all the rest.

In winding up this course of instruction, we will take a short survey, and go through with it at length, and the student may accompany us if he pleases; for we are still of the opinion that practical teaching is the best.

Example.

It is required to sink a vertical shaft on the end of a level or gangway, and the surveys from the bottom of an old shaft are as follows:—

Surveyed with a "Right-Hand" Compass.

			fath.	ft.	in.
No. 1.	356¼°	Length....................................	18	3	0
2.	84¼	"	12	1	6
3.	98	"	15	4	0
4.	A slope 322° (dip 25½°)	Inclined length..........................	11	2	0
5.	107¾°	Length....................................	25	5	6

This is the under-ground work, and our first operation is to find out the dip of the slope, in order that it may stand as a common draft in the survey.

Operation.

The underlay, or angle made by the dip of the slope and a vertical line, being 25½ degrees, we find it standing in the first table against 2 feet 7 inches, showing that every fathom of the slope gives a base of 2 feet 7 inches; and the length of the slope being 11 fathoms 2 feet, we multiply

	ft.	in.
⅓)	2	7
		11.2
4	4	5
		10
4	5	3

Here we find the base of the slope to be 4 fathoms, 5 feet, 3 inches.

The next thing is to refer to the converting table to reduce the drafts into bearings, taking special notice that the work was done with a right-hand compass.

We therefore find that No. 1,	356¼°	is	3¾°	E. of N.
2,	84½	is	5½	N. of E.
3,	98	is	8	S. of W.
Slope, 4,	322	is	28	E. of N.
5,	107¾	is	17¾	S. of E.

Our work is now prepared for entry in the traverse table as data for trigonometrical computation.

No.	Angles and Lines.		Trigonometrical Results.			
Draft.	Bearings.	Lengths. fath. ft. in.	East.	West.	North.	South.
1	3¾° E. of N.	18 3 0				
2	5½ N. of E.	12 1 6				
3	8 S. of W.	15 4 0				
4	28 E. of N.	4 5 3				
5	17¾ S. of E.	25 5 6				

The above is the table with the bearings and lengths of the drafts entered in order for receiving the trigonometrical results in their proper and respective columns; and, that every thing may be clear to the learner, we shall let this table remain as it is, and make a similar one, in which the computations are entered, and proceed to take out the tabular numbers from the first mathematical table, and multiply them by their respective lengths.

First Draft.

	ft. in.		ft. in.	
<3¾° Tabular	0 4.7	Tabular	5 11.85	
	6		6	
	2 2.2		35 11.10	
	3		3	
	6 6.6		107 9.30	
	2.3		2 11.92	
	6 8.9	Easting.	110 9.2	Northing.

Now the sides of the triangle formed by the first draft are ready to be transferred to the east and north columns of the traverse table.

Second Draft.

	ft. in.		ft. in.	
<5½° Tabular	0 6.9	Tabular	5 11.67	
	12¼		12¼	
	6 10.8		71 7.92	
	1.7		1 11.42	
	7 0.5	Northing.	73 7.3	Easting.

When the bearing does not diverge much from the cardinal point, there is but little difference between the length of the hypothenuse and the longest of the legs, as in the right-hand sides of the above two drafts.

Third Draft.

```
                ft. in.                     ft. in.
<8° Tabular  0 10.02           Tabular  5 11.3
                    8                        8
             -------                   -------
             6  8.16                  47  6.4
                    2                        2
             -------                   -------
            13  4,32                  95  0.8
                3.31                   1 11.8
             -------                   -------
            13  1.0 Southing.         93  1.0 Westing.
```

The length of the draft being 15 fathoms 4 feet, we have multiplied by 16, and deducted ⅓ as the shortest method.

Fourth Draft, or Base of Slope.

```
             ft. in.   in.                   ft. in.   in.
<28° Tabular  2  9.8 or 31.8          Tabular  5 3.6 or 63.6
                          5                              5
                      -----                          -----
                      169.0                          318.0
                        4.2                            7.9
                      -----                          -----
                   12)164.8                       12)310.1
                      ---------                      ---------
                      13.8.8 Easting.                25.10.1 Northing.
```

In the above, it will be seen that we have thrown the tabular length into *inches* and parts; and the practitioner will find this, in general, the easiest way of calculating.

Fifth Draft.

```
              ft. in.    in.                  ft. in.   in.
<17¾° Tabular  1 10.0 or 22.0         Tabular  5 8.6 or 68.6
                           26                            26
                          ---                         -----
                          132                         411.6
                          44                          1372
                        -----                        ------
                        572.0                        1783.6
                          1.8                           5.7
                        -----                        ------
                     12)570.2                     12)1777.9
                        ----------                   ----------
                        47.6.2 Southing.             148.1.9 Easting.
```

Now the computations are ready for entry in the following table.

No.	Angles and Lines.		Trigonometrical Results.			
Draft.	Bearings.	Lengths.	East.	West.	North.	South.
		fath. ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
1	8½° E. of N.	18 8 0	6 8.9	....	110 9.2	
2	5½ N. of E	12 1 6	73 7.3	....	7 0.5	
3	8 S. of W.	15 4 0	....	93 1.0	....	13 1.0
4	28 E. of N.	4 5 3	13 8.8	....	25.10.1	
5	17¾ S. of E.	25 5 6	148 1.9	....	....	47 6.2
			242 2.9	93 1.0	143 7.8	60 7.2
			93 1.0		60 7.2	
			149 1.9 Easting.		83 0.6 Northing.	

Now we might proceed to lay down the position or place of our new vertical shaft at the surface without any further operation. For by measuring off from the centre of the old shaft at surface 149 feet 2 inches, due east, and from the end of that line measuring 83 feet due north, would bring us exactly over the end of the fifth or last draft, where the shaft is to come down, but we would work out the direct length and bearing also, as before described, and apply it.

Fig. 167.

Example.

It is required to sink a perpendicular shaft on the end of a level or gangway whose angles and drafts measured as follows, viz.:

			ft.	in.		fath.	ft.	in.
No. 1.	<16° 30′	E. of S.	53	6	or	8	5	6
" 2.	<26° 0′	W. of S.	22	11	or	3	4	11
" 3.	<19° 0′	E. of S.	58	0	or	9	4	0
" 4.	<34° 30′	W. of S.	21	6	or	3	3	6
" 5.	<57° 30′	W. of S.	53	8	or	8	5	8
" 6.	<39° 30′	E. of S.	29	10	or	4	5	10

What distance is the end C in figure 167, where the surveying was finished, from the shaft A, where the surveying was begun, and what is the bearing of the line A C, or how many degrees are contained in the angle B A C?

Operation.

Bases.

	ft.	in.		fath.	ft.	in.		ft.	in.
E. of S. 16°½ =	1	8.44910	×	8	5	6	=	15	2.33790
W. of S. 26° =	2	7.56272	×	3	4	11	=	10	0.53916
E. of S. 19° =	1	11.44091	×	9	4	0	=	18	10.58864
W. of S. 34°½ =	3	4.78125	×	3	3	6	=	12	2.13235
W. of S. 57°½ =	5	0.72418	×	8	5	8	=	45	3.18762
E. of S. 39°½ =	3	9.79763	×	4	5	10	=	18	11.55815

	ft.	in.
Sum of bases W. of S.	67	5.85913
Sum of bases E. of S.	53	0.48469
Base or departure Westerly B C =	14	5.37444

Perpendiculars.

	ft.	in.		fath.	ft.	in.		ft.	in.
<16°½ =	5	9.03502	×	8	5	6	=	51	3.56228
<26° =	5	4.71317	×	3	4	11	=	20	7.16851
<19° =	5	8.07734	×	9	4	0	=	54	10.06606
<34°½ =	4	11.33709	×	3	3	6	=	17	8.62417
<57°½ =	3	2.68557	×	8	5	8	=	28	10.05018
<39°½ =	4	7.55697	×	4	5	10	=	23	0.04485
Perpendicular or difference of latitude, A B								196	3.51605

Then by Construction.

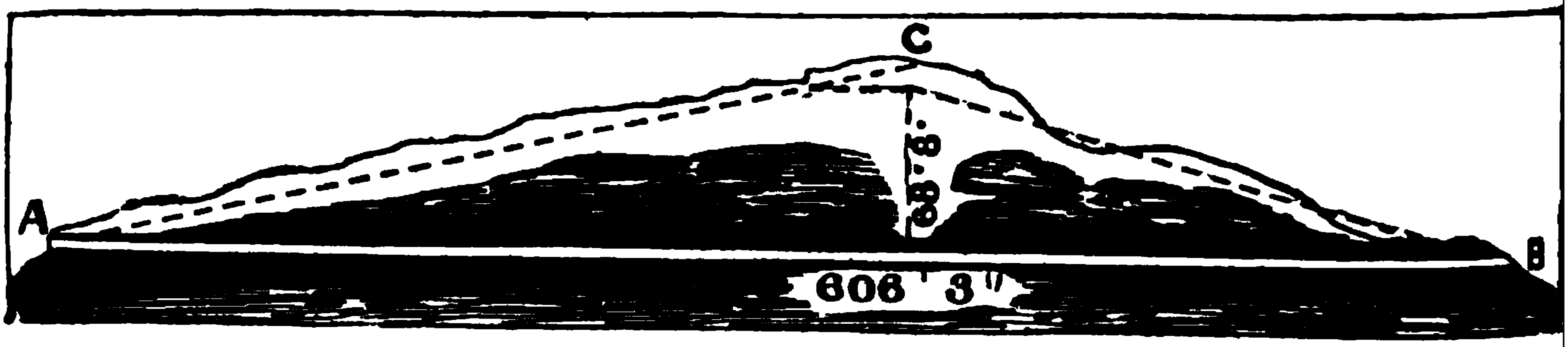
Draw two lines at right angles, as A B and B C, and of indefinite length; take 196 feet 3½ inches in your compasses from a scale of equal parts, and, with one foot in the right angle B, point off the distance B A for the perpendicular. Again, take 14 feet 5½ inches from the same scale, and apply it to the other line B C for the base; draw the hypothenuse to join A C, which by the same scale will be found to measure 197 feet.

Ans. 197 feet, on an angle of 4° 15″ west of south.

PROBLEM.

A tunnel is commenced at the foot of a hill, and is intended to be carried through it. The bearing from the mouth at A, or the course of the tunnel, is required, and the

FIG. 168.



TUNNEL.

point on the opposite side at A, where we may commence to drive towards A. The height of the hill and the length of the tunnel are also required.

The following is the survey from the first point:—

				ft.
No. 1.	Elevation	14°	Length	26
" 2.	"	12¼	"	26
" 3.	"	11	"	17
" 4.	"	18¾	"	90
" 5.	"	10	"	60
" 6.	"	7½	"	119
" 7.	Horizontal	0	"	29
" 8.	Depression	5¾	"	28
" 9.	"	16	"	230

Judging that we have now arrived somewhere near the level or horizontal plane of the start, or that our "depressions" have made good our "elevations," we place an assumed mark at the end of the last or ninth draft, and retire to work out our lines and angles by trigonometry.

OPERATION.

	Perp. ft.	Perp. in.	Base. ft.	Base. in.
No. 1. Elevation 14°, Length 4fath. 2ft., Tabulars	1	5.4	5	9.9
		$4\frac{1}{8}$		$4\frac{1}{8}$
	5	9.6	23	3.6
		5.8	1	11.3
	6	3.4	25	2.9

Thus we find the 1st draft gives a rise or elevation of 6 feet 3.4 inches, and base or horizontal length, 25 feet 2.9 inches; and proceeding in the same manner with all the drafts, and finding the difference between the elevations and depressions, we shall obtain true data for correcting our assumed mark, and replacing it in its proper position.

		Elevation. ft.	Elevation. in.		Horizontal. ft.	Horizontal. in.
No. 1	gives	6	3.4	and	25	2.9
" 2	"	5	6.2	"	25	4.9
" 3	"	3	2.9	"	16	8.3
" 4	"	28	6.0	"	85	4.0
" 5	"	10	5.0	"	59	0.1
" 6	"	14	8.5	"	118	1.0
		68	8.0			
" 7	"			"	29	0.0
		Depression.				
" 8	"	2	8.2	"	27	10.5
" 9	"	63	3.8	"	220	3.0
		66	0.0		606	10.7

Now, as the depressions are 2 feet 8 inches less than the elevations, it demonstrates that our assumed mark is 2 feet 8 inches too high, and as the declination of the ground from the last draft eastward continues on the same angle of depression of 16 degrees, we have perpendicular 2 feet 8 inches and angle 16° to find the corresponding hypothenuse and base; and, by inspection of the second table, we see that the "tabulars" opposite 16° are 1 foot 8.6 inches, and 6 feet 2.9 inches hypothenuse.

Therefore, if 1 foot 8.6 inches gives 6 feet 2.9 inches, what will 2 feet 8 inches give?

Which will be found to give 9 feet 8 inches of hypothenuse.

And by the first table it will be found that 9 feet 8 inches of hypothenuse, on an angle of 16°, will give for the longest side, or base, 9 feet 4 inches.

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ADJUSTMENT.

By removing the assumed mark 9 feet 8 inches due east on the slope, we fix on the exact spot for commencing the eastern end of the tunnel, and we need hardly observe that the two extreme marks mean the bottom or floor of the tunnel.

Then by adding the base, 9 feet 4 inches, made by the corrections, to the sum of the horizontals, 606 feet 10.7 inches, we have just 616 feet 3 inches for the length of the tunnel.

NOTE.—Should it be required to put down vertical shafts on the tunnel, the foregoing computations reveal what their depths would be respectively at all parts of the tunnel; and the deepest shaft would be 11 fathoms, 2 feet, 8 inches at the end of the 6th draft, and 55 fathoms from the western mouth of the tunnel.

PART VI.

CHAPTER XXVI.

GENERAL DISTRIBUTION OF IRON ORES.

The Ores of Iron—Facts and Theories—Cornish Lodes—Mansfeld Copper Beds—Southern States—Lake Superior Copper—Gassan—"Iron Hat"—Sedimentary Deposits and Beds—True Veins, Fissures—Sublimation—Stratified Beds—Ores of the Granite or Plutonic Rocks—The Great Azoic Belt—Geological Horizon irregular—Iron Ores of the Azoic Belt—In North Carolina—In Virginia—In Maryland—In Pennsylvania—In New Jersey—In New York—The Sterling Mountains—New England States—In Canada—Ores of Lake Superior—Iron Mountains of Missouri—Scandinavia.

THE ORES OF IRON.

In the present brief notice of the distribution of the ores of iron, we propose to confine ourselves to the United States, while our description will be more general than special, except in localities where the proximity of coal and iron, or their availability, makes them specially interesting and prominent.

An exhaustive discussion of this subject, illustrating the distribution of iron, the form and locality of its occurrence, and the diversity of the deposits, would demand a larger volume than the work before us; while the facts that might be gathered in relation to the origin, formation, and character of these ores, from the developments made during the last two hundred years, would fill many such volumes, and be of much value to science. But we have neither time nor space at command to give even a condensed outline of the evidences in demonstration of the natural processes to which the ores of iron owe their existence. Such a work, however, is much needed; and some thoroughly practical man, who has made himself a cosmopolitan on this subject, might benefit the world, and confer on himself honor and distinction, by giving the desired information.

We believe the facts existing—if collected, condensed, and compared—would throw much light on the subject of our mineral deposits, and be instructive to the miner and the geologist; and that the natural processes might be traced with almost mechanical accuracy, and the phenomena of vein and seam and bed be demonstrated with mathematical certainty.

FACTS AND THEORIES.

The many theories of the formation of the metallic ores now existing tend to confuse the mind of the student, and it is a difficult matter to select the most probable, since those theories are generally supported by arguments that are convincing to those who are familiar only with the localities to which they apply. But, as most of the existing theories in relation to the formation of metallic veins, seams, and beds are the result of local experience and study, they do not apply generally. For instance, one theory makes all metallic and mineral veins, seams, and beds the result of sedimentary deposits in water; another considers them to be the direct result of volcanic eruptions; a third

advocates the theory of sublimation; a fourth refers the result to electricity, and others to segregation, attraction, gravitation, &c. &c. Now, to any one familiar with the numerous forms and the varied manner in which the metallic ores exist, it will appear evident that none of the theories advanced will cover the ground or account for all the coincidents, but that all are required as a general application.

The Cornish copper lodes of Great Britain are true or fissure veins, and evidently connect with the interior of the earth, and have their origin direct from a Plutonic source. They were filled by sublimation, and condensed by the effects of water and steam. Those of Mansfeld, in Prussia, are stratified in the Permian, and, though the indirect results of volcanic agencies, are deposits or sediments from water. The veins or beds of the Southern States are the results of sublimation, segregation, and sediment, since they exist as sulphurets in connection with copper, lead, gold, and sulphur in true veins, in masses or seams mixed with native copper, and in beds lying in the Azoic slates and the lower Palæozoic slates and sandstones. The copper masses of Lake Superior may belong to later formations than those named, but they owe their origin more directly to volcanic agencies.

The ores of iron result in much the same manner, but perhaps less from sublimation than from other causes, though the oxides of iron generally form the outcrops of all metalliferous veins,—the "gassan" of the Cornish miners, and the "iron hat" of the Germans. This oxidization is always superficial, and results from atmospheric causes. Nearly all metalliferous veins are accompanied by iron pyrites, or oxides of iron. The oxidization of the outcrops sets free the more volatile ores, or, being oxidized, they are washed away by water; while the iron, being harder, and naturally cemented, remains behind. Many such apparent beds of iron exist in the older rocks, and in nearly all formations; but they are neither true beds nor true veins, and, though they occasionally yield a large amount of good iron ore, they are superficial, and depreciate rapidly in quantity and quality as they descend from the surface.

Iron is universally distributed through all animate and inanimate creation, as far as our earth is concerned, and exists in greater or less extent in all rocks,—generally so limited, however, as to be scarcely perceptible, but frequently in large and evident quantities, though not enough for practical purposes, and often in masses pure enough for use, even in those ferriferous rocks which cannot be termed ore-beds.

SEDIMENTARY DEPOSITS AND BEDS.

In the early periods of creation the metallic ores seem to have been less abundant than during subsequent periods. They were either too minutely distributed through the materials of the globe, or too dense to be the first material vented from the condensing earth. We find but little mineral actually existing cotemporaneously with the older rocks, or, if existing, so minutely distributed as to be valueless for all practical purposes. This may be inexplicable to many old miners, who have so often dug the tin and the copper from the heart of the granite; but, if they will think a moment, they will recollect that all such veins are in volcanic districts, and that they exist in fissures formed not only through the granite, but through the gneiss and often through still newer strata, existing on, or over, the gneiss, which proves conclusively that such veins were formed at a period long subsequent to the granite. This seems to be the general rule among the metallic ores. All investigation proves our great metallic regions to be the creation of a comparatively late period, either as the indirect results of volcanic action or of sublimation. Most of our great metalliferous regions, however, exist in the gneissic or Azoic belt, and in the upper portions of the metamorphic. But, as we before demonstrated in the early pages of this work, the Azoic is the great region of volcanic action, for the simple reason that this belt exists along the weakest lines of

the earth's crust, and, being the result of early volcanoes, is in the vicinity of those volcanic vents which filled the Appalachian basin: consequently, it would be natural this should be the great region of volcanic ores.

These facts would not only indicate that the metallic ores are of late production, but that, being more ponderable than the material formerly vented, they are always or generally the last to be vented, on the principle developed in the blast furnace. It might thus be expected that volcanic eruptions of to-day would be more productive of metals than those of former eras; but, as the conditions then existing do not now exist, we could not expect the same natural results.

We are aware that all our sedimentary rocks were formed in water, and that the materials forming them are the results of volcanic action. The logical sequence is that those volcanoes either existed in water or vented their lava into it. Metals are always heavier than their matrix, or the earthy strata in which they are found: thus, if the lava contained a large amount of metal it would be the first to be precipitated to the bottom of the water into which the lava was vented. The lava would not run in a solid stream from the crater and solidify as a stratum in the water, but the moment it touched the adverse element it would be shivered to atoms and thrown back into the atmosphere with the steam it would create, and the lighter portions would naturally arise in dust and ashes, and be carried, by winds and waves and tides, to remote localities, while the heavier material would be precipitated in the vicinity in the order of their density.

This can scarcely be called a theory, since it is a natural process, and one that we know must have occurred. But we do not advance this as the only mode in which our metalliferous beds were formed; it is only one of the many; yet so far it appears satisfactory, and we may refer most of our great Azoic beds of magnetic and specular ores and red oxides of iron to this cause, and their formation to these agencies. We may also refer the alluvial or drift gold in the "placers" of California and the "diggings" of Australia to the same causes.

Gold is washed from the sands of many rivers and the beds of many plains, not only remote from the quartz matrix of gold, but where the streams cross no gold formations. But all such gold washings are in the vicinity of extinct volcanoes or trappean formations. It is scarcely possible that the gold beneath Table Mountain, near San Francisco, in the beds of ancient streams, or the gold that is found beneath the "placers," was derived from the ledges of the Nevada or the quartz veins of the Coast Range, but resulted, in all probability, from the ejection of volcanic matter into the ancient waters. The lava contained gold instead of iron, and the gold was the first precipitated in the manner above set forth, but since the formation of the magnetic ores.

FIG. 169.

TRUE VEINS.

On reflection, it is evident that we could not expect the same results from volcanic eruptions of later ages, since the lava is either vented on dry land, or thrown into deep seas beyond our investigation. The ores or metallic portions of the lava are too minute or limited in amount to make the whole mass rich enough for practical purposes; and since the mass cools and solidifies on dry land without disintegration, the metals are not separated from the matrix, or precipitated, as they would be if thrown in a molten condition on the water. Beds of ore are, however, frequently formed at the base of trappean formations, or between the strata of volcanic rocks, by gravitation or segregation; and this form of seams, veins, or beds is frequently met with in volcanic regions. But we may state, as a general fact, that the metallic ores are the direct or indirect results of Plutonic heat,

except when stratified with the sedimentary sandstones and slates; and even among these beds a true fissure or vein may occur, as shown in figure 169.

We have attempted to delineate, in this illustration, an ideal section, representing the form of true or fissure veins in their course from the granite through the gneiss to the Palæozoic, and even in it. In figure 169, *a* represents the Palæozoic strata, *b* the Azoic, and *c* the granite, *d* an extinct volcano, and *ee* the veins.

On issuing from the granite, the vapors and gases seek vents through the stratified overlying Azoic; and since these rocks and slates are generally stratified at high angles, the vent is formed or forced with much more ease between the strata than through or across it. Thus, we frequently find veins of copper and other ores, though the result of sublimation in fissures, lying between the strata in the form of beds. These veins always seek the weakest line of crust or strata, and, of course, escape where the least force is required to find a vent,—whether it be across the strata or between them, or in the line of faults or slips and dikes formed by former convulsions.

SUBLIMATION.

Most true or fissure veins—those, we mean, of great depth and extending perhaps through the crust of the earth—are evidently the result of sublimation. Though oxidized at the surface, they all merge into sulphurets at no great depth, and become lean, or less rich in minerals, as they descend below the level of condensation.

It is admitted that the interior of the earth is or was a molten mass, existing under a very high temperature,—so high, in fact, that all the known metals would be vaporized unless the tension or pressure from condensation and contraction forced them back into their solids or liquids. But during late ages the contraction of the earth's crust has been less violent, and the volcanic vents, consequently, less frequent. The accumulation of vapors and gases would naturally seek vents through such fissures and crevices as existed, or had been formed by former throes. The upper portions of these fissures terminated in water, and the volatilized metals were thus resolved by condensation into their normal forms. In all fissure veins, however, the ores are mixed with impurities, or a variety of ores are alloyed; but sulphur is the chief accompaniment of all fissure veins. To discuss the various forms in which these veins exist, and the endless variety of the physical and chemical changes to which they are subject, would, as we before observed, occupy more time and space than can be spared. We must, therefore, be content to present the main features; though to be properly appreciated they should be treated fully and exhaustively, since the facts and arguments can be given only in detail.

SEDIMENTARY DEPOSITS.

We distinguish the sedimentary deposits of the Palæozoic formations from those of the Azoic, because they have been formed under different circumstances. Though perhaps the greatest amount of material forming the immense Palæozoic deposits of the Appalachian basin was derived almost direct from volcanic sources, it is evident that those sources were remote, and that the dust, sand, and ashes of volcanoes were carried great distances into the interior basin. It is also evident that much of the material was derived from the debris of older formations brought into the central basins by rivers, waves, and tides. Consequently, the ores deposited in these strata must have been the result of precipitation from a solution held by the waters.

Some of these stratified beds are of great extent, particularly those of the Carboniferous era, found in our coal measures. We can hardly conceive how those immense ore beds, which are almost coextensive with the fields in which they exist, could have been derived from the debris of older formations, since the material derived from this

source would be extremely diversified, and not at all likely to produce a uniform deposit either of ore, sandstone, or slate. It would be a promiscuous *breccia* of every older rock, and an olla-podrida of every lithological formation. We cannot comprehend any natural process by which the changes of beds and strata could be formed, except through volcanic means. A season of rest and quiet forms limestones, slates, shales, or coal-beds; while seasons of volcanic violence form the coarser beds of sandstones, &c. Since all the material of the earth contains more or less iron, it would be natural to suppose that the lava vented from even distant volcanoes, and carried by whatever process into the interior basins, would precipitate this metal in beds. It would find its peculiar horizon of stratification by specific gravity, but the character of the ore would be influenced by the chemical action to which it was subjected.

The fossiliferous ore-beds in the vicinity of the limestones partake of its calcareous nature, while the Carboniferous beds of the coal measures are impregnated with the carbon of the coal.

Chemical action, electricity, gravity, and common segregation may, and in all probability do, exert a great influence in forming either veins or beds of ore; but the chief causes of their production are:—

First.—By the sediment of volcanic matter thrown directly in water, forming beds of magnetic and specular iron ores, gold,* &c.

Second.—By sublimation in true veins and fissures, producing sulphurets of copper, silver, lead, &c. &c.

Third.—By gravitation or segregation from beds of lava and trappean formations generally, forming veins or seams of limited extent and irregular spread.

Fourth.—By precipitation from water holding the ores in solution, and derived chiefly from volcanic sources, but influenced and changed by chemical action and affinity with the proximate formations.

ORES OF THE GRANITIC OR PLUTONIC ROCKS.

But little iron is found in true beds or veins in these rocks, and but few productive ores of any kind are found in workable quantities. It would appear that no metalliferous deposits existed cotemporaneous with the granite crust of the earth. These Plutonic rocks contain much iron, and undoubtedly were and are made up of most of the constituent materials of the earth, but the metals were not separated from the earthy matter in which they exist. Most, and we believe all, of the veins now worked in the granite and its overlying rocks are of comparatively late occurrence, and are the results of volcanic agencies or sublimation.

The iron ores existing in the granites are either the oxidized outcrops of other metallic veins, or the result of decomposing rocks which contain iron in small proportions, or the action of water, in which these oxides form bog ore.

In the coarse or granitoid gneiss, which follows the granites, and which is often hardly distinguishable from the older rocks except in its stratification, we sometimes find small veins or bunches of titanic ore, or an impure, earthy magnetic ore mixed with trap, titanium and quartz.

THE GREAT AZOIC BELT.

In this great zone of rocks, which encircle the entire Appalachian basin, and which have an immense spread in many localities, we find the proper region of the magnetic

* While it is evident that much of the gold found in the beds of ancient streams and the "placers" of our gold-diggings is deposited in this manner, we do not question the fact that much more is produced by the decomposition of the gold-bearing quartz veins.

ores or those peculiar to the trappean formations. The gneissic rocks and associate slates are generally embraced under the nomenclature of metamorphic or Azoic, though the terms do not properly express the character of these formations in all portions of the Appalachian basin.

A simple fact seems to have escaped the notice of our geologists, or if noticed by them our reading has been too limited to observe it.

The Azoic rocks express the meaning clearly as those without the ancient life, or those which contain no fossil remains; as the Palæozoic rocks are those in which are entombed the relics of past races.

The Azoic rocks are crystalline, sedimentary strata, metamorphosed by heat, and, consequently, could not have been formed during a late period, or at a time when life could exist. But the rocks which may be Azoic, or destitute of the ancient life, in the East, may belong to the Palæozoic strata in the West, since all the evidences show that the region of heat was in the East and that the temperature as well as the sedimentary strata decreased to the West and North.* This is not only evident as a natural sequence, but as a fact. It is rare to find fossils in the Potsdam sandstone of the Blue Ridge, or, if found, they are broken, and present evidence that they were not *in situ*, or that they were drifted from other localities or formations. But in the West and North not only the Potsdam sandstone, but several of the underlying formations, are full of well-preserved fossils. It therefore follows that the horizon of the Azoic rocks is not uniform, but that they ascend or descend according to their locality and the conditions of their creation.

In the East this formation approaches very nearly the Auroral limestones of Rogers, or the Valley limestone. It surrounds, as before observed, the entire Appalachian basin, but is not developed beneath the Gulf States, though it undoubtedly crosses from the Appalachian Mountain chain to the Rocky Mountains at some indefinite point south, and encircles the great basin with a zone or belt of unbroken gneiss. In some places this belt is wide and undulating, with comparatively low angles of dip; but in others it is piled in mountain-masses and in oft-repeated and folded strata of the sharpest angles of formation, as in Southwestern Virginia, North Carolina, and Tennessee. In other localities it is low and narrow, as in Eastern Pennsylvania and New Jersey, but everywhere in the East it contains more or less iron ore and numerous veins of copper, lead, zinc, &c. &c. This belt is pierced by thousands of fissures; and extinct volcanoes and trappean formations exist from one end to the other.

IRON ORES OF THE AZOIC BELT.

We propose to commence in the South and trace the ores of this formation around to the West; but, as little development has been made in Alabama, Georgia, and South Carolina in this formation, we shall not notice these States specially, more than to say that many veins or beds of magnetic and red oxide have been found within the limits of their Azoic rocks, but we do not think they will ever be found as productive of iron as North Carolina.

IN NORTH CAROLINA.

North Carolina contains a larger portion of Azoic formation than any other State. Not less than half its territory contains these rocks, while the remainder is made up of recent and Plutonic. The entire Piedmont district is gneissic, extending from the piny barrens of the east to the mountains; but this portion, though rich in gold, lead, copper, zinc, and coal, contains but a limited amount of iron for practical purposes. It is

* We allude to the formations east of the Rocky Mountains.

to her present almost inaccessible mountains that North Carolina must look for her supply of iron; and there the supply is unlimited.

A good topographical map of North Carolina will portray a vast mountain-region lying along the head of the streams and between the waters of the east and those of the west. Along the eastern foot of this great mountain-range are two parallel deposits of ore (we can scarcely call them beds, and yet perhaps they are such), which produce a fine, close-grained, black oxide of iron of the magnetic variety. These beds are not generally large, but regular, and productive of a pure ore, yielding 70 per cent. of metallic iron, or as much as it is possible for an oxide of this class to yield. The ore is generally massive, but frequently granular or friable, and looks like fine black sand on being mined. This variety is much used in the Catalan forges of the mountain-regions described; and, from a personal knowledge of the iron produced, either from the ore direct or from the pig iron of the charcoal furnaces, we can say without hesitation that the world can produce none better, whether from Danemora or elsewhere.

These ranges of ore are very extensive, and in all probability extend from the Virginia line to Georgia. But the points most developed are in the vicinity of Wilkesborough on the Yadkin, Morgantown on the Catawba, and Rutherfordton on Broad River. Near or above Morgantown are some extensive iron-works, which produced a large quantity of superior iron during the rebellion. But, as this range of ore is coextensive with this vast mountain-range, there are other points more available for future use than those named; and one of these is on Smith's River and vicinity, a little to the west of Greensborough and Wentworth. This region is peculiarly rich in minerals, and magnetic and red oxides of iron are abundant, while further to the west are unlimited deposits of copper. This copper region appears to lie in a later formation than that containing the magnetic, and may be referred to the Lower Silurian or Palæozoic, as recognized in portions of the great basin; but we think it is truly Azoic, or so highly metamorphic as to contain no fossils of the ancient life.

The copper region is peculiar. It is embraced in a series of basins lying between the Blue Ridge proper on the west, or the Potsdam sandstone, and the so-called Alleghanies, or Blue Ridge, on the east.* The formation is made up of a frequent recurrence of the upper gneissic strata, and contains several parallel ranges of copper beds. The "gassan" or "iron hat" of these beds often exists in masses of red and brown oxides of great value; while the outcrops of the copper can be traced for many miles in unbroken lines by the masses of iron ore lying on the surface. This great copper region extends from the point of intersection, or where the mountains unite to the north in Central Virginia, to where they meet again to the south in Georgia, and includes the rich deposits of Southwestern Virginia and the celebrated Hiawassee mines in East Tennessee. This entire region, extending along the geological strike of the lithological formations a distance of nearly 500 miles, and from east to west from 50 to 100 miles, is eminently a mountain-district, and in no part of our country this side of the Rocky Mountains are they piled in such grand yet uniform order. Our maps give no idea of their topographical or physical arrangement, and to our geologists, generally, they remain a *terra incognita*. But, from personal investigation, we hazard but little in stating that no mineral region within the limits of the great basin is richer in the ores of copper and iron.

At the point where this great Azoic region is penetrated by the waters of the New River, these ores will be available to the coals of the Great Kanawha, and nature seems to have paved or levelled the way through the otherwise impassable mountain-barriers

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* The Alleghanies, of course, do not enter North Carolina, but divide Western Virginia from Eastern Virginia. The Blue Ridge proper follows the Great Valley range, and is geologically formed by the Potsdam sandstone. The great range forming the eastern escarpment of this mountain-region is named in error.

from those vast coal-fields on the Great Kanawha to the unlimited beds of ore that lie on its upper waters.

Not only do the development of this rich mineral region and the inexhaustible supply of ores to the coals of Kanawha depend on the avenues which may be constructed from one to the other; but the connection of the railroad system of North Carolina with the rivers and railroads of the West must take this route. The passes of the New River are the natural highway of trade from the East to the West, and the iron horse will yet wake their echoes as he speeds in triumphant progress from the waters of Virginia and the mountains of North Carolina to the "Golden Gate" of the Pacific.

The ores of the Azoic belt of North Carolina are not entirely confined to the mountain-region described. Considerable quantities exist in detached masses, in thin, scattered beds, or seams, through the wide gneissic range which lies between the North Carolina coal measures and this mountain region. These ores are magnetic, red oxides, and brown hematites. The magnetics exist in thin seams, or small scattered beds, both east and west of the small limestone range which traverses this gneissic belt. The ores in the vicinity of this saccharoid or crystalline altered limestone are generally brown hematites, and exist in bunches or nests to a limited extent. The red oxides are generally the outcrops of copper veins, &c. But these ores are limited, and cannot be considered of any great commercial value.

The mountain-region described is eminently a mineral region, densely timbered, and extremely inviting to the manufacturers of charcoal iron.

ORES OF THE AZOIC BELT IN VIRGINIA.

The Azoic mountain-region of North Carolina extends into Virginia, but its peculiar basin-shaped formations have only a limited area in this State, embracing only the counties of Floyd, Carroll, and Grayson.

The magnetic range, however, may be traced into Virginia by developments in Franklin and Bedford counties, and its continuation may be noted at intervals to the east of the Blue Ridge through a great portion of Virginia. But, though we have explored this State very extensively, and have shafted at many points on the peculiar magnetic range under discussion, we have never found it in great abundance. The veins or beds are thin, irregular, and much injured by impure matter. In the vicinity of the Peaks of Otter, large quantities of this ore lie scattered on the surface, but we have never been able to trace it to any body, nor have we ever heard of any large masses of magnetic ore being found on this range, or in the region where we would naturally expect to find the largest or most valuable beds of magnetic ores. The trappean rocks, however, which abound in this region are generally impregnated with iron; and the whole Piedmont country, from the Blue Ridge to the Eastern granite ranges, is full of scattered iron ores, impregnating the rocks, coloring the soil, and existing in limited beds of oxidized surface ore, as red and brown hematites and black and red oxides.

In the vicinity of the saccharoid or crystalline limestones, as in North Carolina, there are numerous beds or bunches of brown oxides, but they are of limited extent, and have but little depth. Traced down, they almost invariably terminate in sparry, quartzose slates, or iron pyrites.

Parallel with the gold belts, which appear to be two in number, we find the eastern and western magnetic ranges. The saccharoid limestone and the accompanying oxides of iron exist between these ranges; while the formations containing the magnetic ores appear to be older than the gold to the east, and newer or later than the gold to the west. But the reappearance of the granitoid gneissic in the Peaks of Otter and other elevations of the Blue Ridge offers conclusive evidence of the repetition of the eastern

ranges to the west, and, consequently, the magnetic ores which lie below the gold in the east are of the same ages and formation with those that lie geologically below the gold in the western range, or in the formations bordering on the eastern spurs of the Blue Ridge.

The Azoic belt in Virginia is wide, undulating, and made up of often-repeated axes, folded in sharp and frequently perpendicular strata. The formations are frequently cut by trappean dikes, and the debris of volcanic rocks are found throughout the eastern portion of the gneissic formations. All these rocks contain iron in limited quantities. They appear to exist in their primitive condition, and, though denuded by subsequent floods, were never subject to the disintegrating process, which alone could precipitate their iron. Consequently, we frequently find large masses of black oxides in the eastern magnetic range scattered over the surface, but no beds *in situ* have yet been discovered. We have proved several of the reported magnetic beds of Eastern Virginia, but they all terminated in ferriferous trappean rocks at no great depth, or in impregnated quartzose slates. It is hard to account for the absence of this ore in Virginia in workable beds, since the Azoic belt is very extensive, and trappean rocks or volcanic outbursts are frequent. We can only account for it in assuming that this portion of Virginia was not covered by water at the period of those volcanic eruptions which produced our great Azoic ore beds, since it is evident that their occurrence was long subsequent to the formation of the gneiss in which they exist.

The great region of iron ores in Virginia is in the limestones of the Valley, and between the Blue Ridge and the North Mountains, to which we shall refer in that connection.

IRON ORES OF THE AZOIC BELT IN MARYLAND.

The Azoic belt occupies a limited area in this State. The low shores of the bay extend the Tertiary to the west of its general line in Virginia, and the Mesozoic red sandstones conceal the greater portion of that part of the Azoic not encroached on by the Tertiary. But the metalliferous ranges pursue their course persistent with the strike of the geological formations, and the copper and magnetic ores are found in their proper respective positions as developed to the south.

Beds of magnetic and specular ore exist; but we have not heard of their being productive to any extent. The principal sources of iron in Eastern Maryland are the argillaceous or white carbonate of the Tertiary, and the red and brown hematites of the saccharoid limestones.

IRON ORES OF THE AZOIC BELT IN PENNSYLVANIA.

The Primal and gneissic rocks are less elevated in Eastern Virginia, Maryland, and Pennsylvania than in North Carolina and Tennessee to the south, or in the States lying to the north. They seldom form mountain-ranges in these Middle States, as they do in the Southern and more Northern States. Trappean dikes and the evidences of volcanic outbursts or vents are numerous, and trap rocks of all remote periods are scattered over the greatest part of the gneissic area; but we rarely find beds of magnetic ores to compare with those of the former States. The beds which are developed are in a line of strike coincident with the magnetic ores of New Jersey, and in the lithological strata containing them in North Carolina.

The Warwick mine occupies a position between the lower Palæozoic and the azoic, and the ores are only partially magnetic, changing to brown hematites in their upper strata. This is, however, a true bed, and has been for a long period productive.

Starting from a point near the New Jersey line, northeast of Easton, we find a continuation of the New Jersey magnetic ores developed in Lehigh Hill, though in limited

quantities; again in the Durham mines, south of the former locality. Here the ore is good, and the bed from 2 to 14 feet thick. Still further south we find the Mount Pleasant mines, and near Reading the Penn's Mount mines. Following this general strike, the magnetic ores are found in limited quantities into Maryland; but they depreciate in quantity and quality from the Lehigh south, and but little productive magnetic exists between that point and the mountains of North Carolina, when compared with the immense masses developed in New Jersey, New York, and the Azoic range to the north.

ANALYSIS OF THE ORES OF THE GNEISSIC ROCK OF PENNSYLVANIA.*

Localities.	Peroxide of iron.									100 parts.	Description of Ore.
New Isabella furnace, Chester co.	......	70.20	......	......	......	......	......	2.30	......	99.44	Black, lustre metallic, foliated and granular, magnetic polarity.
Yellow Springs, Chester co.	82.91	......	3.32	1.36	......	......	......	......	12.00	97.56	Brown hematitic ore, lustre resinous.
Metztown, Berks co.	88.92	......	10.60	trace	......	......	......	......	0.20	98.62	Iron black, imperfect crystalline, splendent magnetic polarity.
Millerstown, Lehigh co.	85.50	......	12.00	trace	......	......	......	——	1.35	98.90	Iron black, lustre semi-metallic, imperfect rhombic crystals, magnetic polarity.
Schmuitz farm, Alsace, Berks co.	57.10	24.60	12.10	4.15	0.52	0.40	......	Tit. 0.75	0.26	96.06	Iron black, imperfect crystalline, magnetic specks of hornblende from the richer part of vein.
Half mile east of Reading, Penn's Mount.	36.60	16.25	24.17	6.20	7.10	6.47	3.30	Phos. 0.21	......	97.00	Crystalline magnetic ore, with hornblende, feldspar, quartz, apatite.

ORES OF THE AZOIC BELT IN NEW JERSEY.

The magnetic ores of New Jersey are less massive than those of New York, but the beds are perhaps quite as regular, and the ore about equal in quantity. The eastern range of magnetic ores, as developed in Virginia, does not extend beyond that State. The true range is the western strike, in line with, and parallel to, the Potsdam sandstone of the Blue Ridge.

It appears evident that two outcrops of magnetic ore exist in this range, probably the basined edges of the same beds, since these magnetic deposits follow the strike of the gneissic rocks as uniformly as the strata of a coal-seam. Five beds are worked by the Lackawanna Iron & Coal Company of Scranton in Morris county. Two of these are from 2 to 10 feet thick, and one from 10 to 35 feet in thickness. They are worked by tunnels which intersect the deposits at about 100 feet from their outcrop. The dip of the strata is from 70° to 75°.

These metalliferous Azoic rocks extend through the counties of Warren, Sussex, and Morris in New Jersey, and extend through Orange, Putnam, and Dutchess counties in New York. The metallic belt is narrow in the southern part of New Jersey, but gradu-

* Prof. H. D. Rogers's State Reports.

ally widens in a northern direction. The mountain-ranges in which this ore has been developed in this State are the Marble Mountain, Scott's Mountain, Jenny's Jump, Allamanche, and the Andover Hills, with the Pochunk and Wawayanda Mountains. These ranges form the northwestern margin of the gneissic formations. The southeastern boundary is formed by the Musconetcong and Schooley's Mountains in Warren and Sussex, and the Highlands in Passaic.

The amount of ore developed within those ranges in this State is practically unlimited. The region is opened out by the Morris & Essex Railroad and the Morris Canal, and the mines of this rich and valuable ore are closely connected with the immense stores of anthracite which exist in available proximity. Large quantities of this magnetic ore are used in the Lackawanna coal region at Scranton, and by the numerous and successful furnaces on the Lehigh.

ORES OF THE AZOIC BELT IN NEW JERSEY AND NEW YORK.

"In the Highlands of this State and New Jersey the principal mines occur in two great ranges or systems. Those in the more easterly are the Forest of Dean, the Greenwood, and the Sterling, in this State; and the Ringwood, on the New Jersey side of the line. For the next 12 or 15 miles of its course, no mining operations of any account are carried on at present; but in the same range of mountains, in Morris county, we find the Beach Glen, the Hibernia, the Mount Pleasant, the Mount Hope, the Richard, the Allen, the Swede, the Irondale, the Byram, the Dickerson, and other mines,—all within a breadth of two miles from northwest to southeast.

"The Forest of Dean is five miles from the Hudson River at Fort Montgomery, with which it will shortly be connected by a railroad five miles long, with a descent of 600 feet. The property was recently purchased by the Poughkeepsie Iron Company, who are making improvements with a view to making the mine more productive than formerly. Since the 1st of May about 2500 tons of ore have been taken out and shipped. The number of miners now at work is 25, and about 20 others are engaged in making repairs. The vein worked is 60 feet wide at the depth of 135 feet perpendicular. Iron made from it is of the best quality.

"The Greenwood mines comprise three: the Bull, the Surebridge, and the O'Neill,—the last yielding a celebrated ore. These, with a tract of 8000 acres of land, and an anthracite and a charcoal furnace, are owned by Messrs. Robert P. and Peter P. Parrott, whose guns, manufactured at the West Point foundry, have been in the habit of *speaking* for themselves to some purpose. The product of these mines last year was about 20,000 tons, out of which were made 6800 tons of metal. The anthracite furnace is now idle, but preparing to resume. Number of miners now engaged, about 75; and the whole force of employees is nearly 200.

"The Sterling mine has lately been sold by Mr. P. Townsend to a party of Pennsylvania capitalists, known as the Mount Sterling Railway & Mining Company, who are constructing a first-class railroad to their principal mine, to be operated by steam. They are also converting a charcoal furnace into a hot-blast anthracite, to be driven by a steam-engine of 150 horse-power. Product of the works last year, about 8000 tons of ore, or 3500 of metal. The number of employees in all departments, except railroad-building, is about 135. Mr. Charles T. Ford is superintendent.

"The Ringwood mine, with two forges, belongs to Messrs. Cooper, Hewitt & Miller, who purchased that extensive tract from the Trenton Iron Company. A branch railroad to the Erie is in contemplation. Quantity of ore taken out last year, about 2000 tons. Mr. Philip R. George is superintendent.

"The Beach Glen, the Swede, the Orchard, and the Mount Pleasant mines belong to Messrs. Fuller, Lord & Co., whose extensive works are at Boonton. Number of em-

ployees, about 120; quantity of ore taken out last year, about 24,000 tons. Mr. Robert Oram is superintendent, and in his absence, Mr. Joseph Richards.

"The Hibernia mine is leased by the Trenton Iron Company. A substantially-built railroad connects the works with the Morris Canal at Rockaway, four miles. Raised last year between 15,000 and 16,000 tons of ore. Number of employees, about 40. Mr. Richard George, superintendent.

"Another mine on the Hibernia tract belongs to the Glendon Iron Company, who employ about 125 men. Raised last year nearly 20,000 tons of ore. Mr. George Richards, superintendent.

"The Trenton Iron Company own the Allen, the Dell, the Rosedell, and one of the Hurd mines. Quantity of ore taken out last year, about 20,000 tons. Number of employees now, about 20: three of these mines lying idle. Ore shipped to Philipsburg, where are the company's blast-furnaces. It is thence sent to the rolling-mill at Trenton.

"The Mount Hope mine, with a railroad four miles long, belongs to the Lackawanna Iron & Coal Company, who transport the ore by canal and railroad to Scranton, Pennsylvania, where it is converted into pig and bar iron. Number of employees, about 350, under the superintendence of Mr. Richard Stevens. Quantity taken out last fiscal year, 58,572 tons, of which 7260 were raised in June. Included in the above are the products of the Taylor, the Febo, and the Brannin mines.

"The Thomas Iron Company, of Pennsylvania, own the Richard mine, which turned out about 19,000 tons last year. Mr. D. Jenkins is the superintendent. Number of employees at present, about 75.

"The Irondale mines, half a dozen in number, lie on the south side of the Morris Canal and the Morris & Essex Railroad. They belong to the Sussex Iron Company, who sell the ore to various interests. The number of employees is about 70. Quantity of ore raised in 1864, about 25,000 tons. Mr. John Hance is superintendent.

"The Lehigh Crane Iron Company, of Pennsylvania, own the Randall Hill mine, under the management of Mr. David Jenkins, with 25 men, who took out 4500 tons last year; also the Hilts, the Solomon, and a few others in the western range. Most of these are for the present doing little.

"The Dover Iron Company own the Byram mine, the deepest in New Jersey, the incline reaching to 550 feet without any appearance of exhaustion. A magnificent steam-engine of 100 horse-power has just been put up on the property, under the direction of Mr. Charles King. Nothing has been done here for some years; but operations will soon be resumed.

"The Allentown (Pennsylvania) Iron Company lease and work the Dickerson mine, one of the richest and best in the country, which yielded last year 12,000 tons, and is still keeping up to that figure. Number of employees, 72, under the general superintendence of Mr. Canfield, assisted by Mr. W. F. Potter.

"The Bethlehem (Pennsylvania) Iron Company own or lease the Logan mine, which yields about 500 tons annually; also the Birch and Wilkinson mines on the western range. About a dozen men in all are employed in these works. (New.)

"The principal mines in that range are the Hurd, the Weldon, the Schofield, the Ford, and the Ogden.

"The first of these, on the northeastern shore of Lake Hopatcong, is leased by the Glendon Iron Company, who employ about 45 men. Took out last year, 13,000 tons. Mr. George Richards, superintendent. This year the product is expected to be only 10,000. There are two principal veins on this property, each from 6 to 10 feet thick, and somewhat sulphury, especially near the surface. The Ford mine, also leased by the same company, is now idle; last year, shipped 2200 tons, besides a considerable quantity which could not be sent off.

"The Schofield mine, also idle, is owned and operated by the Lehigh Crane Iron

Company, who shipped about 4000 tons in 1864. This and the Ford are expected to resume shortly.

"The Weldon is an old mine, which lately passed into the hands of a gentleman in Morristown. At present, about 30 men are at work, mostly sinking shafts and driving levels. Took out last year about 4500 tons.

"The Ogden mine is the most valuable on that whole range. It belongs to a company of Pennsylvanians, known as the Ogden Mining, Railway & Manufacturing Company. As implied by this title, they are constructing a first-class railroad, 10 miles in length, from Lake Hopatcong to their property, to be operated by steam. They are also authorized to extend it in both directions, and engage in the manufacture of iron. No ore is being raised at present, on account of the difficulty of transportation. Last year, employed about 25 men, who took out 35,000 tons. Mr. George Richards, superintendent. These veins, five in number, are entirely free from sulphur, and yield iron of the best quality.

"Besides the works mentioned above, there are probably a dozen others, each employing about as many men in brisk times, but for the most part now idle. They are owned by individuals, who sell the ore at the pits or on the canal.

"We are now able to sum up the numbers of men employed at present, and the quantities of ore raised last year, which will be found nearly as follows:—

Owners.	No. of employees.	Product of ore in tons.
Fuller, Lord & Co	120	24,000
Poughkeepsie Iron Co	45	....
Parrott Brothers	200	20,000
Sterling Mining Co	80	8,000
Cooper, Hewitt & Miller	250	4,000
Trenton Iron Co	60	85,500
Glendon " "	170	86,500
Lehigh Crane Iron Co	25	11,500
Bethlehem " "	12	1,000
Allentown " "	72	12,000
Sussex " "	70	25,000
Ogden Mining Co	...	8,500
Lackawanna Iron & Coal Co	850	58,500
Thomas Iron Co	75	19,000
Dover " "	15	....
Others	150	60,000
Total	1,644	818,500

"Besides nearly 10,000 tons of zinc and franklinite ores, employing 200 men."*

It seems scarcely possible that greater availability than this can exist in any of the iron-producing regions of the world. The deposits of ore are large, rich, and productive. The amount of labor required to produce it should be much less than that required to produce the ores of Wales from seams ranging from six inches to two feet in thickness. The coal and limestone exist in quantity and quality superior to any other deposits known. The distances between them are limited, and the means of transportation are ample and cheap. The brown hematites of the valley limestones are convenient, rich, and abundant, and furnish an excellent admixture for the more refractory magnetics.

Under such favorable circumstances, it seems impossible that iron can be produced with greater economy in any other part of the world, since it is impossible that avail-

* From the "American Railroad Journal," September 16, 1865.

able means should offer greater natural advantages. In fact, they can only be rendered abortive by unwise legislation, or that short-sighted policy which opens to the impoverished, starving, and crowded communities of the Old World the markets of the New, by placing our labor and resources in competition with theirs, and levelling our condition, our toil, and our resources down to their miserable standard.

As before stated, the continuation of this metallic or magnetic range continues through New Jersey into New York, extending through Orange, Westchester, Putnam, and Dutchess counties, and from thence, sweeping around through Connecticut, Massachusetts, and Vermont, re-enters New York by Lake Champlain, and produces the celebrated ore deposits of Essex, Clinton, Franklin, and Lawrence.

ORE BEDS OF THE STERLING MOUNTAIN.

Many developments have been made in this formation, and large amounts of magnetic ores are obtained for the furnaces on the Hudson from the beds which exist in close proximity to its banks, in the counties named; but none of these minor deposits will compare in quantity or extent to the magnetic and specular ore beds of the Sterling Mountains in Orange county. It is singular that these immense deposits of the purest ores should have been known and worked for the past hundred years and yet attract so little attention. Here we find immense deposits of the richest ores within 32 miles of the city of New York, equal in extent to the celebrated iron mountains of Missouri, and rivalling the now famous, though lately discovered, iron regions of Lake Superior. Some twenty or thirty veins or beds of black oxide and specular ores have been developed on the Sterling estate, with an aggregate thickness of from 40 to 50 yards. But the Sterling Iron Mountain is the wonder of all who investigate it. So little has been said and so little known of this vast deposit of iron that the stranger is totally unprepared for the surprise that awaits him.

THE STERLING IRON MOUNTAIN.

Sterling Mountain is situated at the outlet of Sterling Lake. It rises from three to four hundred feet above the lake, and its eastern side displays one vast mass of black oxide, of unknown thickness. Enough can be seen, however, to justify the assertion that it is practically unlimited, and contains ore enough to supply the entire wants of the nation for centuries, or perhaps we might say, without exaggeration, that all the anthracites of Pennsylvania might be exhausted to reduce it.

These vast deposits of ore are found on what is known as the Sterling estate, formerly in possession of James Alexander, or Lord Sterling of Revolutionary memory. It subsequently belonged to the Townsend family, who worked it as an iron estate for a long period. Perhaps it is the oldest iron establishment in the United States which has not been abandoned or brought ruin on its possessors.

Recently this estate, which is about thirty miles square and contains 22,000 acres, has been purchased by the Sterling Iron & Railway Company, composed principally, we believe, of enterprising Philadelphians, among others we may mention our great financier, Jay Cooke, and the President of the Company, J. B. Moorhead.

This company are developing the Sterling estate on a scale commensurate with its extent and value. A railroad has been constructed from the iron mountains to connect with the New York & Erie Railroad at a point twenty miles north of Piermont, on the Hudson River. This new railroad is seven and a half miles long, making the railway transportation from the mines to Piermont twenty-seven and a half miles. When this ore is brought to the Hudson River it is open to the markets of the world, and may be taken across the ocean as ballast and there manufactured into iron. But the chief

market for this ore will be on the Schuylkill and the Lehigh, since the empty canal-boats which bring down coal may be loaded with despatch at the wharves of the company and return with their freight of magnetic ores to the anthracite furnaces on those streams. The Sterling Iron & Railway Company have constructed 150 cars for the transportation of their ore, and have made a contract with the New York & Erie Railway Company for the transportation of full trains direct from the mines to Piermont, at which place they have made extensive arrangements for shipping ores, which will be direct from the cars into the boats. These arrangements will enable the company to ship 100,000 tons the first year of their business; and as the demand increases for ore the supply can be increased to almost any extent.

The following analysis, by Messrs. Booth & Garrett, of Philadelphia, gives the constituents of this ore, and the yield of metallic iron.

	Lake Bed.	*Sterling Mountain.*
Magnetic oxide of iron,	94.7	97.6
Silex, or sand,	4.8	2.9
Alumina,	0.3	0.3
	99.8	100.8
Percentage of metallic iron,	68.6	70.7

One ton and fifteen hundred-weight of this ore will produce one ton of pig iron; to reduce which one ton seven hundred-weight of pure coal, with five hundred-weight of limestone, should be sufficient.

The cost of quarrying the ore cannot exceed 50 cents per ton, and its transportation, under ordinary circumstances, would not exceed 2½ cents per ton per mile: hence it can be delivered at Piermont for $1.20 per ton,—or, with profit to the company, at $2.50 per ton under ordinary circumstances; while the cost of transporting it in return coal-boats would not be greater than the transportation on coal,—say, under ordinary prices, from $2 to $2.50 per ton. It is thus evident that this ore can be used at our furnaces with economy.

The rocks of this region are classed by Professor Hitchcock and others as corresponding with the Azoic rocks of Sweden, and the ores are ranked with those of the celebrated Danemora mine. The rocks consist of crystalline granitic gneiss, crystalline or saccharoid limestone, hornblende, and micaceous slates. The ores are accompanied with bands of felspar, or are enclosed in crystalline limestone, associated with garnet, augite, hornblende, thallite, and calc-spar. The rocks and ores are stratified in beds, and dip to the southeast at an angle varying from 30° to 50°.

ORES OF NORTHERN NEW YORK.

The magnetic ore beds of Lake Champlain and vicinity are more limited in size than those of Sterling Mountain, but nevertheless are very rich and productive.

The ores of Clinton and Essex counties are among the most celebrated of the country. They are all stratified with gneissic rocks, and are coincident with them in their line of strike, and frequently so on their planes of dip. The beds vary from two to ten feet in width, and have been worked to a depth of nearly 300 feet. The names of the veins or beds developed are:—the four Arnold veins, the Palmer vein, and the Cook veins, which are four or more in number.

There are but few localities in Connecticut where the magnetic ore of the Azoic belt has been developed; the range, however, may be traced, and the outcrops of limited beds discovered; but we have not heard or read of any considerable amount which has been mined. Spathic ore of good quality exists near Roxbury, and is described by

Professor Shepard as a vein from 6 to 8 feet in size, consisting of pure carbonate of iron, slightly mixed with white quartz.

The ores of this State, like those of MASSACHUSETTS and VERMONT, are chiefly of the tertiary age, and consist generally of brown hematites and yellow ochre, mixed with manganese to a certain extent. These States are not rich in iron ores of any kind, and but little magnetic is found.

NEW HAMPSHIRE and MAINE are richer in ores, and several powerful beds of magnetic black oxides have been discovered, but they have not been developed to any extent. These States are too remote from fuel, and the mountain-regions in which the ores generally exist are not yet opened up for transportation. We merely mention these localities to keep on the trace of the Azoic belt. But, as a portion of that belt sweeps away from the New England States and crosses below Lake Ontario into Canada, we may follow the true metallic range of this belt from Lake Champlain, in New York, into Canada West, and thence around the northern shores of the great lakes to the famous magnetic and specular ore beds of Lake Superior.

The first great deposit we find noticed in the Lake Superior region is the ores in the vicinity of Batchawamung Bay, on the eastern shores of the lake, and about forty-five miles from Sault Ste. Marie. These ore beds are of late discovery, and arrangements are now being made for their development. The mountain-range containing the ore is elevated 900 feet above the lake, and from geological evidences it is, in all probability, a continuation of the ores of Marquette, on the western shores of Lake Superior, since they exist in the same lithological strata, and on the strike of the former ore beds. The thickness and number of the ore beds are not given, but they correspond in character, quality, and quantity with the ore beds of Michigan.

ORES OF THE AZOIC BELT ON LAKE SUPERIOR.

The iron ores of this region are truly wonderful in extent, and though but partially developed, enough ore is known to exist to supply the entire demands of the United States—if available—for many centuries to come. In fact, the ores of the great basin, if only confined to the Azoic belt, seem to be on a scale of equal magnificence with its inexhaustible beds or fields of coal. But when we come to consider the ore deposits of the succeeding rocks, the Valley limestones, the Devonian formations, and the stratified beds of the Carboniferous periods, we may be surprised at their combined magnitude, and exult in the future greatness to which our country may attain with such unlimited resources at command.

There is much diversity of opinion among geologists as to whether the great magnetic deposits should be denominated veins or beds. Some contend that they are the direct results of volcanic agencies, and that those "veins" of magnetic ores were ejected from the bowels of the earth in a fluid and molten state; while others contend that all productive magnetic ores are stratified in beds.

It is scarcely possible that we could expect the same uniformity of strata among the deposits of the Azoic rocks, which are often distorted and recline at all angles in relation to superstructure among themselves. But, to a certain extent, it appears evident that most of the productive magnetic masses are the results of precipitation, as described in the commencement of this chapter; and the order of stratification in which the beds of Lake Superior exist seems to confirm this view.

Figure 170 represents the order in which the ores of this region exist, evincing as plainly as possible a uniform stratification. The rocks which are intercalated with the ores are of volcanic origin, and though not now reposing in the form of dikes, they are true volcanic rocks, disintegrated by coming in contact with water while in a molten condition.

It may be noticed that the ores of this region are various, and consist of black oxides, specular ores, red oxides, brown hematites, &c. The brown hematites appear, however,

LAKE SUPERIOR ORE BEDS.

EXPLANATION.—1 denotes brown hematite; 2, mica slates; 3, red oxides; 4, slates; 5, jasper; 6, magnetic oxide; 7, specular ores; 8, flinty iron ores; 9, specular iron ores; 10, slaty iron ores; 11, magnetic; 12, upper portion red oxide; 15, jasper; 16, gneiss.

to be the upper ores, and resulted, undoubtedly, from the oxidization of the lower ores, and the contact of hot water holding carbonic acid and other chemical agents in solution.

This region lies in the Azoic belt, and the ore beds exist in its upper limits, near the base of the Potsdam sandstone, the position being geologically and lithologically the same as the magnetic range of North Carolina and New Jersey and cotemporary with the same belt in Missouri and Sweden.

AREA OF THE IRON DEPOSITS.

"There is no region of the earth where the ores of iron are developed on a scale of such grandeur, or concentrated in a state of such purity, as on the northeastern shores of Lake Superior. Danemora, Nijny Tagilsk, Elba, or Missouri may contain isolated deposits equally rich; but these combined would occupy a mere patch on the surface over which the ores of this region are known to exist.

"This area is somewhat irregular in outline; its length east and west is 150 miles, with a variable width north and south of from 6 to 70 miles; but the greatest concentration of these ores thus far observed is in township 47, north, ranges 26, 27, and 28 west.

GEOLOGY OF THE IRON DISTRICT.

"The iron region consists of an assemblage of rocks of various kinds, such as argillite, talcose, chlorite, and hornblende schists, quartzites, and occasionally dolomites, all of which are supposed to be of metamorphic origin, intermingled with rocks whose igneous origin can hardly be doubted, consisting of the various compounds of felspar and hornblende, forming greenstone or dolomite; or where silica abounds, forming sienite, or serpentine where magnesia is in excess.

"The region is bounded both on the north and on the south by a series of crystalline rocks in which granite largely predominates. The general direction of the formation is east and west, though subject to minor deviations; and the culminating points, which consist for the most part of greenstone, attain an elevation exceeding 1100 feet above the lake. The metamorphic rocks exhibit a regularly contorted structure, and wherever they approach the purely sedimentary rocks are found to be overlaid by the Potsdam sandstone, whose strata repose in a nearly horizontal position.

MODE OF OCCURRENCE OF THE IRON ORES.

"It may be stated, as a general rule, that the great iron deposits of the district occur in close proximity to the igneous rocks,—mainly greenstone. This rock forms nearly all the prominent rocks of the region, not in continuous ranges, but in a succession of dome-shaped knobs, while the iron ores repose upon their sides or dip beneath their bases, so that the greenstone appears rather in the form of intercalated beds than as wedge-shaped masses.

"The whole has been subjected to a powerful denudation, and the greenstone, being the more unyielding rock, has been left in the form of knobs or of ill-defined ridges. I cannot recall an instance where it forms a true axis of elevation. The beds of iron ore often attain a thickness of four or five hundred feet, and may be traced longitudinally five thousand feet, but they are far from being persistent in character. The quartzose material so abounds that it is only in pockets or lenticular bands that the highly-concentrated ores are found. This is seen at all the mines which have been extensively worked, and the necessity of sinking below drainage has already arisen, and preparations have been made to meet it by driving adits and erecting pumping machinery."*

CHARACTER OF THE ORES.

1. *Manganite, or magnetic oxide of iron.*—No mines have been developed of this ore; but it has been discovered on Lake Machigummi and on St. Clair Mountain. It seems to belong to the lower beds, and is naturally the last to be developed.

2. *Red hematites, or anhydrous sesquioxide.*—At all the working mines we meet with the two varieties, specular and micaceous; and in most specimens can be detected disseminated crystals of magnetic oxide, so that these ores are in fact a union of the two.

3. *Brown hematites, or hydrated sesquioxide of iron.*—These ores appear to occupy an extensive area, and to form part of the rocky structure of the region, but exist as the decomposition of the ores *in situ.*

The above are the principal ores of this region, the specular being included with the red hematites. That these ores are sedimentary deposits cannot be doubted: they not only exhibit a perfect stratification, but present anticlinal and synclinal axes and folds which could not exist in beds or veins of igneous origin. Another conclusive fact is, that much of the specular ore contains fragments of angular jasper in the shape of breccia, evidently the disintegrated portions of trappean rocks which were precipitated with the ores when the molten mass was thrown into the surrounding waters, proving that these accumulations of ore-beds and intercalated schist owe their origin to local causes, or that they are not the results of distant formations, but that they are true beds formed by the flow of molten lava highly impregnated with iron into the waters that existed around and perhaps over the volcanic vents, as described in the commencement of this chapter.

PRODUCTION OF THE MINES.†

"One-eighth of all the iron now made in the entire United States is dug from the mines of Marquette county, and yet ten years ago a piece of Lake Superior ore was a curiosity to most of our practical metallurgists. With the completion of the Sault Ste. Marie Canal, which was opened ten years ago this month, the projects for developing the iron-ore trade assumed a definite shape. The few tons of mineral that had been

* J. W. Foster's Report to the Iron Cliffs Company.

† Dr. R. H. Lamborn's (Secretary American Iron & Steel Association) letter to the New York Tribune.

carted around the portage at the mouth of the lake had proven its value, and the first year saw 1445 tons sent below for smelting.

"The enlargement of the trade has been steady and rapid, as the following statement will show:—

"In 1855, 1445 tons were exported; in 1856, 11,594 tons; in 1857, 26,134 tons; in 1858, 31,135 tons; in 1850, 65,679 tons; in 1860, 116,940 tons; in 1861, 45,430 tons; in 1862, 115,720 tons; in 1863, 185,275 tons; in 1864, 235,123 tons,—making a total of 834,534 tons, which, assuming the ore to yield an average of 60 per cent. (the standard desired by the shippers is a yield of 66⅔ per cent. in the furnace), would give 500,750 tons of cast iron. The development of the manufacture of pig-iron from charcoal, in the county of Marquette, has been even more remarkable, as the difficulties to be encountered in building large structures, erecting new machinery, and collecting necessary labor in a distant and hyperborean region are numerous and serious.

"The earliest iron made was produced directly from the ore, in what is known as the Catalan forge. This manufacture was commenced in 1847, by Everett & Jackson, at the Jackson Forge. After it followed the Marquette Forge, then the Collinsville Forge, and lastly the Forestville Forge, all in the same vicinity, near Marquette. They made iron with more or less success for a few years, but are now in ruins, or so greatly dilapidated that much time would be required to repair them.

"The production of pig iron from charcoal commenced at the Pioneer Works, near the Jackson Mine, in 1858: 1627 tons were sent to market that year. This manufacture has increased by the erection of new furnaces, until at present the Pioneer, the Collinsville, the Forestville, the Morgan, the Northern, and the Greenwood Furnaces are in activity. The progress of the trade has been as follows:—

"In 1858, 1627 tons were exported; in 1859, 7258 tons; in 1860, 5660 tons; in 1861, 7970 tons; in 1862, 8590 tons; in 1863, 8908 tons; in 1864, 13,832 tons.

"Up to the end of 1864, therefore, 53,845 tons of pig iron had been sent to market from Marquette county. By comparing the production of this region with that of other iron districts, it will be found that it produced in 1864 more pig metal than Connecticut or Massachusetts in the same year, and 60 per cent. more than New York in 1850. Reckoning ore and metal together, the mines of Marquette threw into consumption, in 1864, 154,905 tons of metal, or three-fifths as much as the total pig-iron production of the United States according to the census returns of 1850, and, as above stated, one-eighth of all the pig iron produced by the United States in 1864.

"Regarding the method and cost of mining and smelting in this new and isolated region, a few facts will, I am sure, be welcome to our Eastern makers, as well as to that numerous class of Western iron-masters who only know the district through the thousands of tons of rich and pure ore that reach their furnaces from within its limits. I shall not pause to discuss the interesting geological features of the country surrounding the iron-beds, nor the no less interesting points connected with the genesis of the ore itself, but will proceed at once to a consideration of the economic features of the mining and export of the merchantable mineral. The Jackson Company, which exported last year 70,937 tons, the Cleveland Company, which exported 58,838 tons, and the Lake Superior Company, which exported 83,848 tons, are the three principal companies now in operation. The Pittsburg and Lake Angeline, the New York, the Parsons, and the Marquette mines have sent more or less ore to market; while a dozen others are in process of development. They are all situated in what is known as the Azoic range; and those first mentioned are between 14 and 17 miles from the harbor of Marquette.

"The total quantity of ore already extracted, chiefly from the three first mines, is not less than 925,000 tons: yet nothing but 'surface' or 'patch work' has yet been done; all the mineral has been quarried from shallow openings in the sides of the iron hills; no pumping machinery has yet been erected, and only recently have adits for drainage

been begun. The surface-rock indicates in many points that but a portion of the most easily obtainable ore has been quarried; and it is safe to estimate that several millions of tons are proven to exist in the three or four oldest mines, with every likelihood of vast quantities in the beds below water-level. In addition to this are hundreds of localities where iron is known to exist in a belt of 30 miles in length; and at more than a dozen localities companies have been formed or mines commenced. Great skill is not necessary in working these ore quarries. The operation consists in blasting, from a ledge of ore, large masses, which are subsequently broken into fragments by other blasts, by the sledge, or sometimes, in the most refractory cases, by means of a fire of huge logs.

"At the Jackson mine, a hole 18 feet in depth and 2 inches in diameter, loaded with powder and exploded last March, brought down 4000 tons of ore. The holes are all bored with good steel drills, managed by two strikers and one turner. The fragments of ore are loaded into one-horse carts, hauled a few hundred feet to the railroad, thrown into six-ton four-wheel cars, and carried to the wharves at Marquette, where they are unloaded into pockets, or hoppers, or shutes, and thence into the vessels that transport them to the furnace on the lower lakes, or are transferred by wheelbarrow from the hoppers to the vessels or steamboats. The laborers at the mines receive $2 per day, work ten hours, and pay $20 per month for their board. The average product of each laborer—including all whose names are on the pay-roll,—miners, drivers, trackmen, repairers, &c.—is 2 to 2½ tons of ore per day per man. In some cases an average of five tons per day per man has been taken out by a small gang. 91 cents per ton freight is paid on the railroad to Marquette, and the price of ore on the vessels is now $5 per ton."

We might trace the Azoic belt around the great Appalachian basin, by continuing it from Michigan into Wisconsin, where the Lake Superior ores seem to exist in perhaps equal bulk; but for all practical purposes in this connection it would be a useless expenditure of time and space. The data at command is limited; and the region about the Rocky Mountains, and the continuation of the gneiss, are more the subjects of speculation than scientific discovery.

There are, however, several important outcrops or anticlinals of the Azoic rocks within the area of the Palæozoic, and which are even encircled by the coal formations of the West.

The Azoic rocks of Missouri, containing her immense deposits of iron and copper, belong to these isolated groups of gneissic and volcanic rocks, and do not belong to the Azoic belt surrounding the Palæozoic rocks of the great basin which we traced from North Carolina or Georgia to Wisconsin, in following the metallic ranges of that formation.

IRON MOUNTAIN.

The celebrated Iron Mountain of Missouri is the southwestern termination of a porphyritic ridge of from 300 to 400 feet elevation. The front or end of this ridge, which is about 200 feet high, is covered with loose fragments of peroxide of iron, imbedded in red clay. This bed of loose oxidized ore is about 15 feet thick towards the top of the hill, but evidently increases in thickness and solidity towards its foot. The scattered ores are found at a considerable distance from the base of the mountain, and evidently exist beneath it. An artesian well was bored 150 feet deep into these ores. The first 15 feet was through loose ore and clay, the next 34 through beds of sandrock, followed by thin bands of limestone, quartz, and sandstone, and, at the depth of 89 feet, by a bed of pure ore 5 feet thick. Below this was found 7 feet of porphyritic rock, followed by 50 feet of solid ore to the bottom of the well, which did not pass through the bed. Its total thickness is, therefore, not known.

The analysis of a specimen by Dr. Litton, of the Missouri State Survey, gave:—

Silica	0.66	
Peroxide of iron	99.33	
	100	Metallic iron, 69.55

PILOT KNOB.

About six miles to the south of Iron Mountain is Pilot Knob, which is an isolated peak or knob about 580 feet in elevation above the plain, and about 11,000 feet above St. Louis. The rocky strata of Pilot Knob is a dark, silicious slate, distinctly bedded, and dipping uniformly to the south at an angle of 25° or 30°.

The quartz predominates nearly two-thirds of the distance from the base up; but above that to the summit, iron is found in heavy beds, alternating with silicious matter. Some of these beds are very thick, and consist of pure micaceous and specular ore, which shows a slaty structure, while that of Iron Mountain is without cleavage.

The other localities at which ore is found in this region are Little Mountain, near Iron Mountain, and Shepherd's Mountain, near the Knob; while the "Bogy Bank" and Russell Bank produces good ore.

An analysis by Dr. Litton of the ore from Pilot Knob gave:—

Silica	12.03	
Alumina	1.61	
Peroxide of iron	86.07	
	99.71	Metallic iron, 60.27.

It will be observed from the foregoing description that these celebrated iron mountains are not all iron, as many suppose, and as might be imagined from the tenor of the Missouri State Reports; perhaps less than one-tenth of the bulk of those mountains is

PILOT KNOB.

solid or valuable ore; but even under such a limited estimate the amount of available ore in these celebrated deposits is practically inexhaustible, and is sufficient to supply the iron industry of Missouri, and, in fact, a great portion of the West, for ages to come,

without reference to the large amount of brown hematite and other ores which are scattered through this region.

"The mountain-masses of Missouri have pre-eminently the eruptive character, and are associated with rocks which have always been considered as of unmistakable eruptive origin. The iron region of Lake Superior, which is even more extensive and more abundant in ores than that of Missouri, is another instance of the vast development of these ores in the Azoic.

"In the State of New York, in the same geological position, we find the same occurrence of the specular and magnetic oxides, and almost rivalling with those of the regions just mentioned in magnitude and importance. Here, however, the evidences of direct eruptive origin are perhaps less conspicuous, and the deposits seem, in many cases at least, to exhibit the appearance of a secondary action having taken place since their original formation. In this region these ores have in their mode of occurrence the most striking analogy with those of Scandinavia. Like them, they generally coincide in the strike of the rocks in which they are enclosed, forming lenticular or flattened cylinder-shaped masses intercalated in the formation. The enclosing rocks are similar in character to those of Sweden: they are gneiss, quartzose, and hypersthenic rocks.*

"Although the ores of the Azoic have not always a purely igneous origin, yet even in these cases where they bear the most evident marks of having been deposited in beds parallel with the formation, with the presence of water, we must acknowledge that pre-existing eruptive masses may have furnished the material from which they were derived. That the Azoic period was one of long-continued and violent action cannot be doubted: and while the deposition of the stratified beds was going on, volcanic agencies, combined with powerful currents, may have abraded and swept away portions of the erupted ferriferous masses, rearranging their particles and depositing them again in the depressions of the strata. This seems the most probable origin of some of those lenticular beds parallel with the stratification, where it is difficult to conceive of a fissure always coinciding with the line of strike of the formation, and where the mechanical evidences are wanting of the thrusting up of such masses of matter, which we know could not have taken place without many dislocations of the surrounding rocks which would have made themselves very apparent."†

* These ores were noticed under the head of New York, particularly in connection with the Sterling Mountain.

† Whitney's Metallic Wealth of the United States.

CHAPTER XXVII.

IRON ORES OF THE PALÆOZOIC FORMATIONS.

Ores of the Lower Silurian Rocks—The Great Valley Limestone Range—Nests, Beds, Fissures, and Basins of Ore—Prominent Localities of Brown Hematite—Mount Polk Furnace, Alabama—Round Mountain—Etowah Ore-Banks—Chattanooga—Lonachucky—New River Ore-Bank—Laurel Dale—The Blue Ridge—Clover Dale—Gun-Metal—Ores of the South Mountain—The Iron Hills of Cornwall—Theories of Formation—Formation of Brown Hematites—Extent and Availability of the Brown Hematites—The Stratified, or Sedimentary Ores—Oxidized Outcrops—Ores of Cambria and Danville—Ores of the Coal Measures—Analysis of the Ores of the Coal-Fields.

The ferriferous region which we propose to describe under this head lies principally in the limestones and slates of the Great Valley range, between the Blue Ridge and the Alleghany Mountains, or the brown hematite region, between the Potsdam and Medina sandstones and the stratified ores of the Carboniferous formations, but inclusive of the beds lying intermediate or in the Devonian rock.

The Valley range is the great region of brown hematites, and embraces generally the Primal slates, the Auroral and Matinal limestones of Rogers, or the Hudson, Trenton, Chazy, and Calciferous limestones of the New York geologists, and the Galena and Calciferous limestones of the West.

These rocks have a wide distribution, and are only separated from the Azoic by the Potsdam sandstones in the East, and probably a lower formation of fossiliferous strata in the West, resulting from the comparative quiet and low temperature that existed there, in comparison with the violence and heat of this period in the East as before stated. These formations, therefore, follow closely the Azoic belt, but on interior lines, and they are, consequently, of more limited extent, but form the base of the vast Palæozoic formation filling the great basin; and, since they are from one thousand to five thousand feet in thickness, the area occupied by these limestones is not only extensive, but widely distributed.

Starting from the alluvial deposits of the Gulf, they traverse the northeastern part of Alabama, the northern part of Georgia, and form the beautiful and productive valleys of East Tennessee; the great Valley of Virginia through that State, from Bristol in the southwest to Harper's Ferry on the Potomac; the rich Cumberland Valley in Maryland and Pennsylvania, and the magnificent regions around Harrisburg, Lebanon, Reading, Allentown, and Easton; through the northwest corner of New Jersey, and by the valleys of the Hudson River and Lake Champlain through New York into Canada; and thence, ascending the St. Lawrence, skirts the north shores of Ontario, and, passing through the Georgian Bay of Lake Huron, sweeps round the north and west sides of Lake Michigan, and pursues a nearly west course through Wisconsin to the Mississippi. The granitic and gneissic mountain-regions of Northern New York are thus placed inside of this limestone belt; but this may be explained by the fact that the Palæozoic limestones and slates divide to the south of this gneissic elevation and pass around it to the eastern shores of Ontario, thus encircling this isolated Azoic formation by the later Palæozoic strata.

Those eastern and northern outcrops of these rocks are well defined and of great thickness and extent. The western margins are not so clearly shown; their outcrops are thin, indefinite, and but seldom seen. Several anticlinal axes of the lower Palæozoic strata arise within the Great Basin. One traverses Middle Ohio, Kentucky, and

Tennessee, between the Alleghany and Central coal-fields, and spreads west around the southern end of the coal formations in Missouri, encircling the Azoic rocks of the Ozark Mountains, and bounding the Washita Hills in Arkansas and the granite peaks of Central Texas; while within the Eastern Appalachian chain several anticlinals of this limestone appear in Pennsylvania and Virginia.

IRON ORES OF THE GREAT VALLEY RANGE.

As before observed, this is the great region of the brown hematites, or the hydrated peroxides of iron. These ores were not formed in the manner of the Azoic magnetic and specular ores. They are never found in strata or intercalated with the limestones and slates in or on which they exist, but are invariably formed in bunches, "nests," or irregular masses, in the hollows and crevices of the limestones, or in the soft clays which border the outcrops of the lime against the sandstones and slates, both to the east and west of the valley.

The eastern side of the valley, or where the limestones, slates, and shales are stratified on the Potsdam sandstone, is its most persistent bed; and here may be found a range of brown hematites which extend from the Chattahoochee in Alabama to the Lehigh in Pennsylvania, and how far beyond may be inferred from the extent of the formation. But between the points named the writer is familiar, and states the facts from practical sources. This range of ore is persistent, and may be found at any point within the distance named, but it is developed in far greater abundance at some points than others. Through Tennessee and Virginia it exists in an almost unbroken line, but made up of constantly-changing deposits. Here we may find a thin, irregular stratum of ore imbedded in clay, there a mountain mass of moss-grown rocks of iron; here a mere string of ore, or simply red or ochry clay, and there a succession of "nests" distributed without strike or conformity.

Fig. 171.

"NESTS" OF BROWN HEMATITE.

On the higher grounds of Southwestern Virginia, in Pulaski, Wythe, and Smyth counties, this ore presents a partially stratified appearance, and exists in immense beds lying in the clays, which always accompany it, but never stratified between other rocks. We have never seen sandstones or slates overlying it, except where the contractions of the accompanying rocks have forced themselves over it in inverted form.

On the northwest side of the valley this form of structure or deposit is not so prominent, though the same character of nests, bunches, and masses is found. The distribution is not so general, and the amount of ore is much more limited. It is sometimes found as the oxidized outcrops of ferriferous slates, or in a stratum on or between thin bands of limestones, sandstones, and shales; but these deposits are limited and have but little depth.

In addition to those two general ranges of ore, we find deposits of this hematite scattered promiscuously through the valley from edge to edge,—in some places assuming the shape of ridges and hills; in others we find it deposited in the hollows or crevices of the limestones; sometimes lying against the face of sandstone rocks which traverse the valley, and in so many other forms that it would be tedious to describe them.

These deposits are never deep. They are always found in bunches or shallow basins in the soft clays which fill the depressions of the limestones, and on or between the rocks without regard to conformability.

Though the Azoic belt contains an incalculable amount of iron ore, and mountain

masses exist which would seem sufficient to supply the wants of the world for thousands of years, we hazard nothing in stating that more available ore exists in *this* parallel range, from Alabama to Lake Superior, than exists in *that;* and that the brown oxides of the limestones are more than equal in quantity and quality to the magnetic and specular ores of the gneiss.

PROMINENT LOCALITIES OF THE BROWN HEMATITES.

We shall not be able to name but a very few of the many prominent localities where this ore exists in large bodies.

In Alabama, the Carboniferous or mountain limestone approach so near the Silurian rocks and the valley limestones, and their ores are so similar, that we shall make no distinction.

The ores found at Red Hill, on the southern edge of the Alleghany coal-field, and in the western portion of the State, belong to the Carboniferous limestones. It is rich, and exists in great quantities. That at Selby county, at Columbiana, and elsewhere, is in the Silurian. These ores are extremely rich, and yield about 60 per cent. of metal in the furnace.

At the MOUNT POLK FURNACE, in Benton county, we examined several large masses of this ore that may literally be called mountains, and which contain, probably, as much ore as the famous iron mountains of Missouri. Several varieties exist there:—a compact, lustrous, and crystalline ore, used in the bloomeries for the production of wrought iron direct; a loose, gravelly ore, made up of solid, angular fragments, and hollow balls, or "geodes" of every size and form; a hard, porous, or fibrous ore, which, though extremely rich, melted easily and made excellent iron, and a yellow oxide, or ochreous ore.

In this vicinity there are several valuable "ore-banks," or deposits of brown hematite, and also a fossiliferous, red oxide, which exists in strata, and produces an excellent fibrous iron from the blast-furnace.

The Coosa coal-field lies about ten miles from these deposits. The coke produced from the coal of the upper portion of this field is extremely pure, and productive of good, soft iron from the cupola or the furnace.

At the BLUE MOUNTAIN Iron Works, and in the vicinity of Talladega and Gadsden, are also some extensive and valuable ore banks of both brown and red oxides.

At the Round Mountain Iron Works we find the fossiliferous red oxide (a lenticular ore) used exclusively

This ore always exists as a bed, but always as the upper formation, and resting on

ROUND MOUNTAIN.

the sandstones of the Devonian series, if we mistake not, though resembling very nearly the ores of Montour, in Pennsylvania, though richer and softer. But, as all these ores

lie on the face of the hills, or have but little stratified covering, they are naturally highly oxidized and soft.

The strata dip in the Round Mountain to the northwest at an angle of about 45°. The upper face of the mountain is covered some ten or twelve feet deep with the ore, but towards its base it runs under the cover of the slates, sandstones, and limestones, which basin at no great depth; the opposite outcrop has not been discovered. Near this point, a short distance above, and about thirty miles below Rome, are the CORNWALL FURNACES of the Messrs. Noble, operating on this fossiliferous red oxide and charcoal,—as, in fact, all the furnaces of Alabama are worked.* The ore in this locality is very extensive, and productive of excellent iron. This range of red oxide may be traced for a hundred miles on the west bank of the Coosa, with but little interruption, except where denuded. We presume it to be coextensive with the Eastern Appalachian chain; but nowhere is it so largely developed, or so productive, as in Alabama. In the vicinity of Rome, Georgia, and the mountain ranges to the east of the Lookout, from the Coosa to the Tennessee, are numerous and extensive deposits of both brown and red oxides.

At the ETOWAH IRON WORKS, between Kingston and Atlanta, extensive ore banks are developed in the "eastern range" on the edge of the valley. These ores are brown hematites exclusively, and partake of the character of this range generally. From this point to Jonesboro, in East Tennessee, these ores exist at intervals in every hill-side and ridge projecting from the western foot of the Blue Ridge, and in the eastern edge of the valley. At some places they are developed in masses, and all points more or less available ore exists.

In the vicinity of Chattanooga, and in North Georgia generally, vast beds of brown oxide and fossiliferous red oxide are found, and used to a considerable extent.

At the LONACHUCKY IRON WORKS, some eight miles east of Jonesboro, the brown hematites of the Eastern range are developed in immense deposits,—consisting of dense and massive conchoidal, or "liver ores," porous, or fibrous ores, and yellow, or ochreous ores. These works have been in operation for nearly fifty years, though idle at intervals; and while all the near or available timber has disappeared, no impression has been made on the ore.

From this point to Marion, in Smythe county, Virginia, the Eastern range of ore may be traced in almost unbroken beds or deposits; and from Marion to the "Old Lead Mines," in Wythe county, the ore is found in immense masses, and generally in the form of a stratum of almost solid ore, which has a clean, smooth fracture; is hard, yet brittle; dense, yet not refractory, and is extremely pure and productive, and has been extensively used in the bloomeries or Catalan forges for the production of wrought or bar-iron direct. In the vicinity of the lead-mines, in Wythe county, are several furnaces which have been in operation some thirty years or more, and which have realized fortunes for their proprietors. But they do not all obtain their supplies from the Eastern range. David Graham's New River furnace is supplied from crevices in the limestones, and shallow deposits on the face of the ridges; but the amount so distributed is inexhaustible as the supply of a single furnace.

North of this point, in Pulaski county, are the ore banks of the LAUREL DALE IRON Company. This deposit is massive in structure, and irregularly stratified in the soft clays which lie at the base of the Blue Ridge, or, more properly, the ridges which project from its western slope. All through Pulaski and Montgomery counties this range may be traced with almost unbroken ledges and masses of ore along the Blue Ridge. But at this point a greater development of ores has taken place than elsewhere in the valley, as far as our experience goes.

* With charcoal.

THE NEW RIVER ORE-BANKS.

Not only on both banks of the New River are the brown oxides of the limestones found, but the red and brown oxides of the copper-region are also penetrated by this stream. It runs for fifty miles through the rich limestone valley, abounding in iron and lead, and then enters the Azoic formations to the east, formerly described in this connection, where immense masses of red and brown ores exist. Below the valley, or west of the valley limestones, the river enters the mountain-ranges of the formations overlying the Matinal. These mountain-ranges are made up of heavy sandstones, slates, and limestones, and contain numerous masses of brown ores, as developed in Giles, Craig, Monroe, Alleghany, Mercer, and Tazewell counties.

These ores may not be of any great value for the production of iron locally, because the timber to produce charcoal will not be adequate or in proportion, though the mountain or Azoic region in Floyd, Carroll, and Grayson counties is almost an unbroken primeval forest, and the counties before named, to the west of the valley, also possess an abundance of timber; but these resources are insignificant, when compared with the resources of this region in iron ores.

But the Alleghany coal-field is in available proximity, and the coals of the Great Kanawha and the ores of the New River, in Virginia and North Carolina, are both on a scale of equal magnitude. We will not exaggerate if we compare the resources of the Kanawha in this respect to the most favored localities in Pennsylvania, not even excepting the Lehigh region, with its coal and iron. The only requirements are enterprise and capital to develop these resources and to combine the coal and the ores by rail.

IRON ORES OF THE BLUE RIDGE.

From this point north the Blue Ridge will be recognized as a common name. South of the New River it is known by various names, and the name has even been applied to the eastern mountain-ranges in North Carolina.

The pioneers of North Carolina, approaching these ranges from the east, might well mistake these Azoic mountains for the Blue Ridge of Virginia, since both topographically and geologically the eastern side of one resembles the other. But the Potsdam sandstone forms the highest elevations of this mountain-range, if we except the granite peaks to the east, and, as this rock underlies the limestones and follows them, the Blue Ridge proper must be parallel to the valley.

The ores of Laurel Dale, just alluded to, lie in the ridges projecting from this mountain and in the eastern range of brown hematites. From this point in Pulaski county to Botetourt county, this ore has not been practically developed, but evidences of its existence are plentiful along the entire line. At the Clover Dale furnace in the latter county, it has been in use for over thirty years for the production of gun-metal, which has supplied the Bellona and Tredegar gun-foundries since their establishment for the manufacture of most of their guns. During the rebellion it was in full blast, and we understand several furnaces in the vicinity were repaired and put in operation, while other new furnaces were built.

Still further north, on this range, is Glenwood furnace, which, however, does not produce the best iron, on account of some impurity of the ore. But near this point, and north of the pass through the Blue Ridge, where the James River leaves the valley, are the "North River ore-banks," which supplied the Westham furnace with most of its ore. The deposits, however, are limited, and the "nests" irregular, but the ore is very good, and may be traced in unbroken lines to the Buena Vista furnace, some twenty miles further to the north. Occasionally this ore is mixed with manganese, and from the pass of the James River to the head of the Shenandoah streaks of this mineral

exist parallel with the ore. In some places it is found in large quantities to the injury of the iron.

From the Buena Vista furnace, in Rockbridge county, to Harper's Ferry, this range of ore has been worked at various places; but, on account of the scarcity of the timber, most of these old ore-banks are now abandoned. Still the ore exists, and in former times large quantities of iron were produced by the furnaces in this part of the valley.

We cannot mention all the localities in the valley of Virginia where the brown hematites exist in prominent masses, but may state that on both sides of the valley, and at many points in its interior, large and valuable deposits have been practically developed. We may name those at the Roaring Run furnace, Etna, Vesuvius, Cotopaxi, Cliffton, Dolly Ann, &c. &c.

ORES OF THE SOUTH MOUNTAINS.

These mountains are a continuation of the Blue Ridge of Virginia, in the same geological formations and with the same ores; but here the Primal slates and sandstones, including the Potsdam, are repeated and undulated in folded axes. The range of the valley limestones through Maryland is limited to a narrow strip, but the same lithological structure is maintained, and the same ores in the same geological position are found corresponding with those before described. We may here remark that the eastern range is not in the valley limestones, but rather on the Primal rocks bordering this side of the valley.

As before noticed, the eastern range of brown hematites frequently develops in large masses or deposits on the western flank of the Blue Ridge. The South Mountains are formed by an enlargement or spread of the Blue Ridge range, which bends to the west through the Cumberland and Lebanon Valleys, forming a crescent, with its horns at Harper's Ferry and Reading, and its radius at the South Mountains.

The South Mountain "ore-banks" are about the centre or most western point of the bend, and among the ridges or Silurian hills which flank the western sides of the Azoic mountains. On the opposite or eastern flank are the magnetic ranges before described, but here concealed by the Mesozoic sandstones, which are pierced by the trappean rocks peculiar to the Azoic, which the Mesozoic conceals.

The ore is, we believe, entirely brown hematite, but diversified by the varieties which always exist in those mountain masses,—such as the compact, crystalline, porous, honeycomb, ochreous, and manganite,—forming of themselves a good mixture for reduction in the blast-furnace.

Manganese is generally found accompanying the brown oxides of this eastern range, as it sometimes is in that of the west and in the isolated deposits of the valley; but it is seldom intimately mixed with the ore. Certain layers, however, contain appreciable quantities, and the ore can be used in the furnace with or without it. When used in the shape of manganite, from 5 to 10 per cent. can be mixed with the burden of the furnace to great advantage in the reduction and improvement in the quality of the iron produced.

When very soft pig-iron is required, the manganite is not used; when hard iron is required, it is used in large quantities; but when strong, fibrous iron is desired, a moderate quantity can be used to great advantage.

It is not generally known that a judicious mixture of this ore with a variety of the brown hematites not only saves flux, but operates with much economy in the reduction of fuel. We have tried numerous practical experiments in this respect, and found that almost any quality of iron might be produced by those mixtures, and that a reduction of one-third the quantity of coal was not only possible, but eminently practical.

The value of our magnetic ores depends on their fusibility, or their purity and yield.

They, however, generally contain a small amount of manganese when found in the vicinity of limestone, as in some parts of the Sterling Mountain of New York. In such cases they are more calcareous than silicious, and are reduced with a less amount of fuel than when highly silicious and refractory.

A charcoal-furnace and bloomery has long been in operation at Mt. Holly, and are supplied with ores from the South Mountain ore-bank. The iron produced has always been celebrated for its strength and tenacity, particularly when in the shape of bar-iron, and the blooms produced from the ore direct command an advance above the general market price.

These ore-beds, or banks, have recently been purchased by the South Mountain Iron Company, of which Hon. Henry D. Moore, of Philadelphia, is President. The estate embraces 20,000 acres of ore, timber, limestone, and farming-land. The ore-banks are about 14 miles southward from Carlisle, on the Cumberland Valley Railroad. Arrangements are now being made to connect the mines, or banks, with this line, which will put them in direct communication with the anthracite furnaces of the Susquehanna, thus providing a source of supply much demanded by these furnaces, and a large and growing market for the production of the mines.

An analysis of the South Mountain ore, made by Du Bois & Williams, of Philadelphia, will be found below. It gives a high percentage for this class of ores, and compares favorably with the general yield of the Lake Superior or Cornwall ores. Forty-five per cent. is above the average yield of our brown hematites; but we have reason to think that the ores of the South Mountain will exceed that amount, and when selected will yield fifty per cent. in the furnace.

Analysis of the South Mountain Hematite.

Peroxide of iron	78.78
Peroxide of manganese	8.50
Silex or Silica	2.20
Water and loss	11.52
Metallic iron, 54.47	100.00

THE IRON HILLS OF CORNWALL.

This singular deposit of ores is, we believe, peculiar to the locality. They are produced by the intrusion of a trap dike, which originates in the Azoic, though bursting

through the overlying Mesozoic, near the South Mountains, and which enters the valley near Cornwall in Lebanon county, Pennsylvania. Here the volcanic or trap

eruption terminates between the limestones of the valley and the primal slates, but in the great Eastern range of brown hematites which we are tracing.

The form which these igneous rocks assume at this point is suggestive. Generally they spread out on the surface and conceal the crater, if such existed; but here they form a crater, or separate so as to form a dish-shaped rim of trap nearly around the deposit of ore. These volcanic rocks contain but little iron, and present no evidence of having emitted the iron of this deposit from the bowels of the earth. We find here masses of iron almost in a metallic state; but it is evident that these are the result of the great heat which operated on the brown oxides of this locality, existing before the intrusion of the trap. This volcanic rock proves itself of late origin, because we find it piercing the overlying Mesozoic.

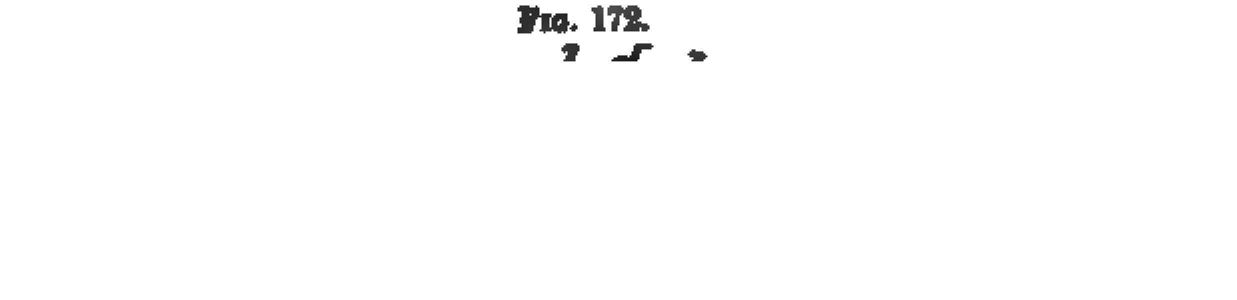
The ores of Cornwall are not purely magnetic, but contain a small portion of brown oxide, sulphurets, and oxides of copper.

The formation of these ores is peculiar. They are evidently sedimentary, but owe their occurrence chiefly to the action of volcanic heat on the accompanying rocks, and perhaps the waters acting on the sublimated vapors, escaping from the fissures formed by the ejected trap, or through the influence of both combined.

Prof. Rogers, in his Geology of Pennsylvania, thus explains the formation of this peculiar deposit:—

"At this locality the actions collecting the oxide of iron into its present conditions have been somewhat complicated. The ferruginous Primal slate has been metamorphosed, and its oxide of iron segregated and crystallised through the influence probably of highly-heated volcanic steam, and the same influence has produced a very general cleavage structure. During the same action, or subsequently, numerous injections of molten hot lava, resulting in dikes of trap rock, have invaded the stratum, and have still further changed the condition of the mass, infusing among it, probably by sublimation, some trappean mineral matter, and especially some sulphuret and carbonate of copper; and since these subterranean influences, the atmosphere, through its rains, has exerted itself through countless ages to modify still further the chemical and physical condition of the shattered and fissured mass and its contained oxide of iron.

FIG. 172.



TRAP BASIN AT BIG HILL.

EXPLANATION.—*a represents magnetic* boulders of fused and *almost metallic* iron, closely resembling the "salamanders" of a chilled furnace, and evidently the results of volcanic heat on the brown oxides which existed in this locality prior to the invasion of the trap. On the north side, at *a*, the Auroral limestone overlies the Primal slates *c*, but on the south side, at *d*, the Mesozoic red sandstones overlap these slates (*c*) in an unconformable manner; *bb* are the enclosing or encircling trappean walls. They are 600 feet apart at the surface or outcrop, but only 400 feet asunder at water-level. Several smaller offshoots of trap pierce the central mass of ore, but these appear to have intruded subsequently to the formation of the ore; *oo* is the central mass of ore which is stratified in a nearly horizontal manner; *d* is the location of the principal body of copper ores, and *c* the Primal slate *through which the trap has burst.*

"This great iron-ore deposit, by far the most extensive and one of the most interesting in the State, is situated at the outcrops of the Primal upper slates, where they rise from beneath the Auroral limestones, in Lebanon county, on the southeast border of the Kittatinny Valley.

"The ore-strata are embraced in three hills, having a nearly east-and-west range. These hills are flanked on the north by the Auroral limestones, and south by the overlapping unconformable Mesozoic red sandstone, which forms a high ridge, prolonging east and west and overlooking the valley.

"The eastern or 'Big Hill' is elevated 312 feet above the level of the creek at its base. The middle hill is 98 feet high, and the western hill 78 feet high.

"The bounding wall of the ore in the Big Hill is a heavy dike of trap, which varies in regard to texture and composition as the feldspathic or hornblendic element predominates. This massive dike, the thickness of which seems nowhere less than 40 feet, and probably greatly exceeds this, encircles the hill on three sides."

It appears that this bounding wall of trap also exists on the fourth side, but is concealed by debris. These walls of trap form a basin or receptacle for the ore, as shown in figure 172.

Iron ores occur in so many different forms, and under so many chemical combinations, that no one theory of formation can cover the coincidents and conditions with which and in which they are found. This deposit of ore differs in character and structure from the ores of the great limestone region which we have been tracing; but the material change must be ascribed to the trap dike which here invades the mineral range, and the volcanic heat which must have accompanied it; and perhaps the solution given by Prof. Rogers is the best theory that can be offered.

FIG. 173.

To account, however, for the formation of the isolated hematitic masses found throughout this great limestone region, or the continuous range of hematitic ores which exist along the eastern slopes of the Blue Ridge, we must seek some other theory. But since there are so many theories we shall decline the task, merely presenting such facts in relation as may shed some light on the subject.

FORMATION OF THE BROWN HEMATITES.

ORES IN THE LIMESTONE FISSURES.

The hematites, or brown oxides, do not appear to exist except in the vicinity of limestone: yet there is no evidence of their originating from the limestones, since these rocks contain but a small proportion of iron. The ferriferous rocks of this region are generally those which underlie the limestones, though the overlying sandstones also contain the ores of iron in various forms. Throughout the great valley range the deposits of ore are generally found on the slates and sandstones, or between the limestones and overlying or underlying rocks. But when the limestones are stratified horizontally, covering or concealing these rocks, the ore is always found in fissures, as represented in figure 173.

It would therefore appear that the substance forming these ores is obtained from other formations than the limestones, but that the chemical action which separates, segregates, or precipitates them, is supplied by the latter.

Where the limestones and the ferriferous slates and sandstones meet, these ores are generally found in "nests," deposited in beds of clay, as shown in figure 171. The great mineral range which exist on the Primal slates, or between them and the overlying limestones, and which we have traced from Alabama to Pennsylvania, is always in such beds of clay, and almost invariably accompanied by manganese. These beds of clay are peculiar to this locality and range. They are singular in character and form, and are made up of almost all colors, from the most delicate pink and red to the purest white, and from the most tenacious, adhesive, and plastic nature to the most loose, friable, soft, and treacherous quicksands. In the harder clays, the nests of ore are

usually found, but they are frequently cut through by quicksand courses. We also find in connection with these nests of ore large bodies of fine ochreous powder, resembling "Tripoli polish," and almost equal to crocus in its effects on metals, when the finer quality is selected.

The ores of these clay deposits are always in basin-shape, though often cut down and through by erosions. They do not lie deep, and are very irregular in size, constantly increasing and decreasing in extent, and only occasionally existing in great masses.

The brown hematites of the western side and centre of the valley, when existing on the slopes of the sandstone formations, or between the limestones and the underlying rocks, are not generally found in nests, or enclosed in masses of clay, and the ores are more massive in structure and harder in character, though generally less in quantity. They are seldom, however, stratified, and are generally accompanied with limited bodies of clay, in which they are imbedded.

The ores found in limestone fissures are much the same in character, and always accompanied by clay to a greater or less extent. This form of deposit is extensively developed at the Ironton mines, and the hematite formations on the Lehigh generally. Most of the hematites furnished to the numerous furnaces on the Lehigh River are from the limestone fissures. Some of these mines, we learn, are 200 feet deep, and we have not heard of any bottom being found. We should expect such fissures to reach the underlying slates or sandstones; but we do not think any of them are very deep, since they generally exist where these lower formations are in close proximity. At great depth we have generally found such fissure deposits to terminate in iron pyrites, or the sulphurets of other minerals to predominate,—such as lead, zinc, copper, &c.

These fissures could not have been filled from the surface by precipitation, since in that case, instead of the narrow fissure containing all the ore, we might expect to find it abundant on the surface, or around the fissure. But that is not the case: the fissure alone is filled,—not with the formations which surround it, but with iron and clay, which were produced from or by the lower rocks; and we have no doubt but that the fissures themselves were created by the accumulated gases which sought vent either between the formations, as at the junction of the limestones and the underlying rocks, or through them when nearly horizontal, and offering no other means of escape. Sublimation, therefore, must have produced most of our brown hematites. But they may also have been formed by the decomposition of iron pyrites and the disintegration of the ferriferous rocks. But sublimation, internal heat, volcanic steam, and water, with the action of subsequent frosts, fires, and atmospheric changes, have, no doubt, produced much of our highly oxidized ores. We find the outcrops of calcareous, carbonaceous, argillaceous, and other ores greatly changed from their normal condition, and assuming the character of brown hematites: in fact, this seems to be the result of all oxidization when perfect; though there are other forms in which such ores exist, as red oxides, &c. &c.

CONTINUATION OF THE VALLEY RANGE.

We have only a few words more to say in connection with this subject. We have, in the early pages of this work, given the range and extent of the Auroral and Matinal limestones as coextensive with the Primal rocks, or the Palæozoic formations of the continent, and closely following the gneissic belt before described. It would be tedious to follow this formation in its vast range to the north and west as we have traced it from the south, nor would our time and space admit of such a course. We do not think this great limestone belt is as productive of ore to the north as to the south; but that the hematites exist throughout the range in large and available quantities, the many developments which have been made abundantly testify.

But the hematitic regions are not confined entirely to the limestones of the Auroral and Matinal periods. The brown hematites are also found to a limited extent among the limestones of a later period, and in the mountain or Carboniferous limestones of the coal-fields. These formations, however, do not produce these ores in equal abundance with the older limestones; in fact, their occurrence is rare, except where they constitute the outcrops of other ores, or ferriferous strata. But the evidence we have given of the abundance of the brown hematites within the great basin sufficiently demonstrates its unlimited and inexhaustible supply.

The locations of these ores are such that they are brought in close connection with the coals of the anthracite fields on the Susquehanna, Schuylkill, Lehigh, Delaware, and Hudson Rivers. On the lakes and Western rivers the ores descend to the coal, and proceed in procession to the markets. In the South the same thing happens; on the Kanawha, the Tennessee, and the Coosa, the ores descend to the coal, and both proceed together to their markets. The ores of Lake Champlain and the Hudson, and the coals of Pennsylvania, advance to meet each other, and then both take the same route to the place of consumption. On the Lehigh, the Schuylkill, and the Susquehanna, the coal descends to the ores, and both join the procession to the markets of the East. Thus, the distribution of both ores and coal is eminently available and in practical proximity.

THE STRATIFIED OR SEDIMENTARY ORES.

By sedimentary ores we mean the stratified or bedded ores of the coal-fields, and those of the formations immediately preceding the coal measures. To this class belong the fossiliferous ores of Bloomsburg and the block ores of Danville, the stratified ores of Broad Top and Hollidaysburg, the "lenticular" ores of Western New York, the ores of the upper Susquehanna, and the "fibrous red oxides" of Tennessee and Alabama. The fossiliferous, "lenticular," and "fibrous" are red oxides, and exist principally in the "Surgent" series of Rogers. The ores of the Meridian formations succeeding are mostly brown oxides, and exist in thin layers imbedded in clay, and generally in contact with or in proximity to the limestones of that era. The ores of the "Cadent" and "Vergent" series are generally calcareous or fossiliferous,—but partake more of the red than the brown or hydrous character. All these beds of ore are thin, and not generally very productive; but they are widely distributed, and generally rich in metallic yield near their oxidized outcrops: they depreciate, however, when protected by heavy strata of impervious rock or slate from the action of *frost* and *heat*, water, wind, and sunshine. But below those influences these ores are lean, thin, and expensive to mine. The rich red oxide (fibrous) of Tennessee and Alabama lies on the face of the ridges, generally without covering, and always open to the influences of water, frost, and heat. But when not exposed to those influences, they are neither rich nor available, being lean, silicious, and hard. The process of deoxidization to which these ores have been subjected disintegrates and changes the structure of the mass, separating the particles of iron from the earthy matter, leaving the latter in dust or clay, and the former in concentrated mass.

This process is singular, but it is not confined to these beds alone. All stratified ores with which we are familiar, except the rich carbonaceous ores of the coal-fields, are subject to like influences when exposed on their outcrops or when concealed in the earth.

The calcareous ores of Johnstown, in Cambria county, now used so extensively at the Cambria Iron Works, were extremely rich at their oxidized outcrops, and yielded double their present percentage of metallic iron. The red oxides of Danville were rich and promising when first developed, and for a considerable distance under cover their yield was good and they were mined at a reasonable cost; but, on being followed below

water-level and beyond the influences of the atmosphere, they became lean and thin and are now abandoned as not available.

These ores are generally the result of precipitation in water, from the ferriferous material which it contained, either in solution, or as derived from volcanic eruptions. They are seldom or never rich in their normal condition, but exist simply as ferriferous strata, and only develop available ores when exposed to the chemical action of heat, water, or atmospheric influences.

These ferriferous beds exist throughout the Palæozoic formations in every grade of richness from two or three to fifty per cent. of metallic iron. We find these strata outcropping everywhere in the anthracite regions; but, unfortunately, they seldom contain enough iron to become, through oxidization, available in the furnace. But many of the argillaceous and silicious ore-beds of the anthracite measures could be used with economy in the blast-furnace, if mined at available rates. By slow calcination or long exposure to the elements, the clay and silex disintegrate and the iron separates from these earthy impurities, leaving them generally in the form of dust or fine-grained powder, which, under a process of crushing and washing, can be entirely separated from the ore and with much economy in use.

ORES OF THE COAL MEASURES.

The ores of our coal-fields are numerous and widely distributed; but, unfortunately, their beds are generally thin and their yield is low. But, though not as rich as the mine-ores of South Staffordshire, England, they will compare favorably with the ores of the Welsh coal-fields, which are so extensively used in the blast-furnaces of Wales.

The table of analysis which we take the liberty of copying from Rogers's State Survey shows the average yield of the anthracite ores to be equal to the yield of the Welsh ores; while the yield of the ores of the bituminous measures is in excess.

In the anthracite regions these beds of ore do not present favorable positions for mining with economy: they are generally enclosed in heavy walls of hard rock, and are generally too thin to mine without removing the accompanying top or bottom strata. In a few cases they exist above coal-seams and in such close proximity as to admit of one being mined with the other; but this is the exception and not the rule.

While the red-ash measures contain more of the ferruginous rocks, and we find iron diffused more generally through their measures, among the white-ash beds of coal are found the most consistent beds of ore,—that is, the ores of iron exist in peculiar strata rather than diffused through the mass. We frequently find small beds of ore in the vicinity of the conglomerate; but these are thin, irregular, and lean. The first important ore-bed which we find in the anthracite regions is above B, or the Buck Mountain coal-bed, and in the vicinity of C. This undoubtedly produces the ores which we find so frequently cropping out behind the Mammoth throughout the anthracite regions; and not only the anthracite, but we find it also consistent throughout the Great Alleghany coal-field.

It is developed at the Barclay and Blossburg mines, and used extensively at Johnstown, in the Cambria Iron Works, and is found and used extensively in Armstrong, Venango, Clarion, Mercer, Butler, Beaver, and Alleghany counties; while on the Great Kanawha, in West Virginia, it is found on its consistent horizon over the ferriferous limestone.

This bed of ore varies in the anthracite regions from twelve inches to thirty inches in thickness, and yields from 20 to 40 per cent. of iron. It is, however, extremely silicious in the anthracite measures, but contains a small percentage of lime and manganese. This ore is a protocarbonate wherever found, always containing more or less carbonate of lime, and sometimes a small amount of the carbonates of magnesia and manganese. In the bituminous regions it is sometimes a calcareous ore, containing so large an

mount of lime as to become a ferruginous limestone. The outcrops of this bed are lways oxidized, and present either a red or brown hematite, in which case it is very ich and productive.

In the vicinity of the Mammoth we find several small seams of ore; but they are not f a size or character ever to render them available for the production of iron to any xtent.

The second bed of importance is in the vicinity of the Primrose, G. This is a black and, and may be the same as that which is developed in the Bear Valley basin, though re are not familiar with the locality of this black band in that basin. We know, howver, that the Primrose bed does not extend far in that direction.

There are numerous small beds of ore among the red-ash coal-seams, frequently n close proximity to the coal, and always above it. Most of hese ores may be mined with economy; but their silicious haracter will prevent their use in the blast-furnace, unless prepared, as before stated, by burning, crushing, and washing. This process is not expensive, and the ore resulting can be reduced with a comparatively small amount of flux and a corresponding proportion of coal.

Fig. 174.

COAL AND IRON.

The accompanying figure, 174, represents the combination of coal and iron as found generally in the English and Welsh coal-fields. The connection of coal and iron is also found in the same proximity in the anthracite red-ash beds, but the proportional amount of ore is much less, while the coal is generally much greater.

In some portions of the Richmond (Virginia) coal-field, particularly in the Deep Run basins, a carbonate of iron overlies the principal seam, as represented above, but the ore is less and the coal greater in proportion, as in the case of the anthracite red-ash seams.

ORES OF THE BITUMINOUS COAL MEASURES.

The principal bed of the bituminous fields is that which we have mentioned as existing above B, or in connection with the buhrstone or ferriferous limestone. This bed seems to be coextensive with the measures in which it exists, which spreads over the greater portion of the vast Alleghany coal-field, and, perhaps, may be found as extensive as the horizon of coal-bed B, or the limestone which it accompanies.

Its thickness varies from one to four feet, and its yield of metallic iron is from 25 to 50 per cent. If each square yard of this seam is capable of producing one ton of iron —which is a low estimate—throughout one-half the area of the Alleghany coal-field, the total amount on comparison would sink into insignificance the celebrated iron mountain of Missouri and cover out of sight the great iron regions of the lakes.

But this ore, when mined beyond the influences of the atmosphere, will not produce good iron without an admixture with the brown hematites of the limestones or the ores of the gneissic belt, and these, as we have shown, are always available to our great manufacturing centres. A combination of the magnetics and specular ores, which are "cold-short," with these calcareous ores, which are "red-short," produces a good iron for all ordinary purposes; while an admixture of hematites with the calcareous ores answers the same purpose.

There are two prominent seams of iron ore found in the lower coal measures of the Alleghany field. The second lies some distance above the *buhrstone* ore, and in the vicinity of the Freeport, or Curlew, limestone. The exact locality of this ore we cannot fix, but believe it to be on the same horizon with the ores in the vicinity of the Mammoth

bed of the anthracite regions. But this ore is less reliable than the first, and is not so persistent in its spread. On the Great Kanawha it is found in workable dimensions, and its outcrops may be found at intervals throughout this great field; but it is seldom developed in a condition to attract attention.*

Fig. 175.

Sandstone

Ore.

Limestone.

Sandstone.

Coal.

CALCAREOUS ORE-BED.

The accompanying figure, 175, illustrates the position of the calcareous or buhrstone ore, and its connection with the accompanying limestone and coal.

There are many theories—and some of them very elaborate—advanced to account for the formation of peculiar ore-beds. But we do not see any reason to speculate beyond the common and natural processes, which we can readily comprehend, to account for the formation of the sedimentary beds of our coal-fields. We find them generally deposited on beds of coal, limestone, or shale; and we can no more wonder that a bed of ore should be stratified over thousands of square miles, than that so many beds of sandstone are deposited in uniform strata throughout the Appalachian basin. The ore is more dense than the sandstones and slates with which it is found, and is the first to be precipitated from every great volcanic eruption. We find, however, the presence of lime important to the chemical separation or segregation of the iron from its accompanying earthy matrix; and, though not invariably, we generally find the ores purer and in greater quantities in the vicinity of limestone than when beyond its influence.

The character of the ore is due to other causes; and when we find the carbonate of iron in the coal measures and in connection with its coal-beds, we are not surprised that it is not peroxide, sesquioxide, or magnetic oxide, but consider it the natural consequence of its contact with the carbon which then existed in profusion throughout the coal measures and the waters in which they were deposited.

We shall not attempt to trace or describe the uncertain ore-beds in the upper coal-series. The extent of the coal measures lying above the Mahoning sandstone is limited, and the ore-beds which they contain are of small dimensions and uncertain character. We know but little more than that several such beds exist in the upper measures.

With this brief notice of the ores of the great Appalachian formations we must close this chapter; but we cannot dismiss the subject without a few words in relation to the magnitude of our iron deposits, their great variety, boundless extent, and availability.

Magnificent as our coal-fields are, they do not surpass our resources in iron; for both are on a scale of magnitude corresponding with the vastness of the country in which they exist and the population which it is destined to support.

A bountiful Providence has stored our mountains with unlimited supplies of the most valuable of minerals. The valleys and plains teem with productiveness, the land is rich in corn and wine, and the bowels of the earth fat with oil. We may invite the poor and oppressed of the world to come and partake; but we must protect ourselves against the monopolists and oppressors of the Old World, if we would profit by the abundance of the New.

* We have not noticed many small seams of ore in the bituminous measures, though many of them are larger than those which are mined with profit in the Welsh mines, and equally rich, as may be noticed in the accompanying tables.

ANALYSIS OF THE IRON ORES OF THE COAL MEASURES.*

			Carbonate of Manganese.	Carbonate of Lime.						
Gate Vein, Pottsville	30.85	......	......	1.06						
North American Mines	30.83	......	......	1.00						
Rabbit Hole Vein	63.30	......	......	1.60						
" "	48.33	16.04	2.68	3.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Pottsville (locality uncertain)	67.80	......	1.80	0.39	......	29.00	1.30	1.50	33.9	
McCarty's Tunnel	26.02	19.36	......	0.07	4.04	46.40	2.08	1.00	26.39	
Salem Vein, Guinea Hill	56.20	......	......	......	0.03	39.30	2.80	.20	32.48	
Guinea Hill	67.40	......	......	1.26	2.00	21.00	1.00	1.40	34.72	
" "	63.30	......	......	......	1.04	3.20	2.60	.40	30.06	
" "	31.53	31.51	......	......	......	31.06	......	6.06	37.14	...ternally, hard, blue, meagre.
Mann & Williams Tunnel	72.00	......	......	2.06	1.52	21.50	1.00	3.00	36.00	
" " "	79.20	......	......	......	......	15.00	2.60	1.60	42.8	[illegible]
St. Clair (furnace bank !)	42.88	21.82	2.64	......	......	27.06	......	5.03	34.96	Externally concentric, brown, internally blue.
St. Clair (furnace bank ?)	66.67	2.55	......	3.25	......	13.90	2.25	6.10	33.06	Slate blue, compact.
Mt. Laffee	29.34	14.57	0.50	......	......	40.00	......	4.60	32.52	Brownish, compact, meagre.
"	45.50	......	1.00	6.00	7.50	30.00	2.25	7.00	22.06	Blue, compact, crystals of iron pyrites.
"	29.44	15.56	0.30	......	......	39.00	0.50	4.50	31.50	Brown, slaty, slightly unctuous.
Zachariah's Run	31.07	14.37	1.26	......	2.20	44.80	1.00	5.00	26.06	Bluish, slaty, micaceous.
" "	35.13	26.10	2.29	6.93	8.79	21.62	0.71	1.00	41.38	Dark blue, slaty and compact; more external brown crust.
Port Carbon	......	53.56	1.05	......	......	36.01	......	9.35	37.14	Dull brown, laminated with clay
Summit Mines, Lehigh	......	37.40	......	......	......	45.55	18.60	4.00	22.96	...usty.
Black Spring Gap, Dauphin co.	73.94	10.36	2.95	......	2.07	6.63	......	7.99	42.22	
Near Shamokin	54.90	24.90	......	......	......	16.06	1.00	1.50	44.87	
" "	74.50	......	......	6.40	......	14.20	2.80	2.59	35.96	
" "	63.20	......	1.00	......	......	31.16	1.50	1.60	30.52	
" "	58.00	3.45	4.50	......	......	15.44	4.60	7.50	45.92	
Big Mountain, Shamokin	......	79.50	......	......	......	4.90	......	12.60	55.66	...pecimen.
Wilkesbarre	57.00	1.20	1.00	1.50	0.30	38.00	3.00	4.50	30.10	Bluish gray, slaty.
Lackawanna Valley	39.10	14.05	1.00	2.00	1.00	33.10	3.00	5.00	32.50	Bluish, conchoidal.

* Prof. Henry D. Rogers's State Report.

ANALYSIS OF THE IRON ORES OF THE COAL MEASURES.*

Bituminous Localities.	Carbonate of Iron.	Peroxide of Iron.	Carbonate of Manganese.	Carbonate of Lime.	Carbonate of Magnesia.	Silicious Matter.	Alumina.	Water.	Metallic Iron.	Description of Ores.
Karthaus, Clearfield co., below B.	19.86	34.90	......	4.50	......	30.40	1.70	5.20	33.96	...tic.
Paint Creek, Cambria co.	60.90	12.60	......	3.00	......	14.74	2.00	6.50	36.22	
Clearfield Creek, Clearfield co.	50.48	12.79	......	0.70	2.43	29.01	......	4.50	33.77	
" "	56.53	13.21	1.13	......	1.26	24.41	......	3.16	34.11	
" "	68.37	20.49	2.25	1.07	2.08	6.10	......	1.64	46.64	
Bear Creek Hill, Tioga co.	44.79	6.41	0.88	......	1.09	37.28	0.34	6.28	27.06	
" " "	......	26.89	0.22	......	0.44	59.36	1.88	10.52	16.51	by layers.
Warner's, Clearfield co.	52.56	......	......	8.00	......	36.80	......	2.00	26.95	
" "	73.81	4.24	......	......	......	14.46	1.00	5.50	35.59	
Blairville, Westmoreland co.	71.19	......	......	3.50	2.72	17.56	2.10	2.70	34.37	
" "	67.20	7.45	......	3.24	1.50	12.34	......	6.00	37.24	
Lockport, Westmoreland co. (bog ore)	......	77.60	4.56	......	......	4.00	1.50	12.00	56.90	
Lockport, Westmoreland co.	69.60	......	......	7.80	......	20.44	......	2.40	33.52	
" "	45.30	......	2.30	32.00	4.50	9.46	1.26	6.00	21.86	
Scrubgrass, Venango co.	96.00	......	......	......	......	2.10	0.50	1.00	41.30	
	79.90	......	.06	2.60	......	14.80	0.50	2.00	38.05	
	76.30	......	0.50	6.00	......	13.50	1.00	2.00	39.03	spathose.
	87.04	......	......	4.06	......	5.06	0.5	1.06	54.14	
	......	76.22	1.50	......	......	4.80	0.54	14.20	54.75	
	......	76.01	......	......	......	7.70	3.60	12.60	53.27	
Porterfield Furnace, "	26.50	46.04	1.00	1.78	21.50	0.70	4.00	4.00	56.03	
" " "	......	79.20	1.00	......	......	5.30	......	14.00	55.44	
Shippensville, "	......	83.00	2.00	......	......	2.61	......	12.50	58.10	
Buffalo Creek, Armstrong co.	66.32	......	......	13.84	1.66	10.68	......	4.00	32.96	...ular, compact.
" "	54.38	......	......	......	......	40.99	0.60	4.09	26.34	Silicious.
Smuller's Furnace, Venango co.	......	80.12	0.50	......	......	3.80	......	13.10	56.07	Brownish yellow soft and pulverulent (bog ore).
Hickory Furnace, Butler co.	......	78.60	0.40	......	......	4.80	......	14.00	55.02	Cinnamon brown, brittle, with plates of hematite (bog ore).

* Prof. Henry D. Rogers's State Report.

CHAPTER XXVIII.

THE PRACTICAL DEVELOPMENT OF OUR RESOURCES.

Our Resources—The Knowledge which *is* Power—Development—Policy of England—Policy and Resources of the United States—Protection *vs.* Free-Trade—First Tariff—The Revolution—First Crisis—Tariffs of 1824-28—The Compromise Act—Second Crisis—Tariff of 1842—Ad Valorem Tariff of 1846-7—Third Crisis—The Slaveholder's Rebellion—Tariff of 1861—"The Protection of War"—The Wealth of Nations—Political Economy—Its Objects—Cheap Labor—The Farmer and Planter—The Miner, Manufacturer, and Mechanic—Practical Illustrations—Cheap Labor *vs.* Free Labor—Importation of Food—High Prices—*Cui Bono?*—Middle Men—How to pay our Debts—Our Foreign Debt—Domestic Debt—National Loan—Gold *vs.* National Currency—Finances—Commerce.

Our resources in coal and iron are unlimited. Both in quantity and quality they are superior to all competition. The rest of the world combined will not compare with our single country in the one nor the other. We possess thirty-four times the quantity of coal and iron possessed by England, and perhaps double as much as that possessed by all other portions of the earth. These resources are availably located; they are in proximity with the widest plains and richest soils known to man. They are developed by ocean-like lakes, or magnificent rivers, and are, or will be, traversed by railroads from ocean to ocean. Their value is incalculable, their extent boundless, their quantity immeasurable, and their richness unequalled. The wealth they represent cannot be told in figures. The dynamic power they intrinsically possess is beyond computation. They offer us the control of the world,—its wealth, power, and destinies. We may profit by the power thus offered us, and benefit mankind, or we may ruin ourselves, and entail greater misery on the poor and oppressed. We may multiply and scatter these bountiful provisions of Providence; we may ignorantly reject them, or basely, wantonly, squander them. On our intelligence, prudence, and industry will depend our welfare and the profit we may derive from the magnificent resources at our command.

"Knowledge *is* power,"—notwithstanding the doubtful shaking of heads among mere "book-worms," or the students of the "dead languages,"—that knowledge which "teaches us to pierce the bowels of the earth and bring forth from the caves of the mountains metals which give strength to our hands, and subject all nature to our use and pleasure."

That knowledge is power which enables us to multiply our productiveness, to substitute the iron limb and rib and wheel for human thews,—to increase our strength a hundredfold, and exchange our thoughts, our labor, and our productions, so as to profit most by the diversity of our wealth, and diffuse that wealth through the community.

We did not and do not intend to inflict our readers with a lecture on Political Economy; but, having displayed and illustrated the magnitude of our mineral resources, it is now proper and appropriate to illustrate their practical development, and the ways and means of making them available to our domestic industry and our political economy.

We will try to be concise and practical. We will not treat the subject *scientifically*, because older and wiser heads than ours have been confused over the subject. Adam Smith and the English have been trying to teach us for the last hundred years, by science, metaphysics, and *coercion*, that it is profitable for us to *sell them* "rabbit-skins at sixpence, and buy back their tails at a shilling."

The policy of England has been wise, but selfish; profitable, but oppressive. She has grown rich by keeping the world poor. We do not advocate her policy; but, by

showing how she acquired wealth, power, and influence, though circumscribed, limited, and insignificant in resources when compared with ours, we may best illustrate the practical development of our fields of coal and mountains of ore.

THE POLICY OF ENGLAND, AND HER DEVELOPMENT.

The practice of England is at variance with her precepts. Her history does not agree with her "political economy," as taught by her sophists. Her practical economists have not followed their teachings.

A short time ago,—measuring time by the life of nations,—the English were serfs, "villeins," or painted savages, and their rulers petty feudal chiefs. They then fought with each other, or disputed the possession of their little island with the Scots, Irish, Picts, and Welsh. But Christianity brought them civilization, and foreigners taught them the arts and sciences. They improved their time, and profited by their lessons. The miners of Cornwall dug tin and copper from their barren hills and sold it to the Phœnicians, who taught them the art of making iron.

In 120, a military forge was erected at Bath, near the well-wooded hills of Monmouthshire; and the bed of iron cinders in the forest of Dean, where Roman coins were found imbedded, testify the early production of iron. But during the succeeding generation our British ancestors were neither wise nor prosperous. They spent their time in brutal civil broils or fruitless foreign wars. Their sovereigns granted monopolies to favorites. The poor were tasked to pamper the noble. Manufactures were discouraged, taxes were heavy, but the revenues were small. England had neither strength, wealth, nor power.

Necessity, however, compelled the production of iron, and as early as 1620 the destruction of the forests began to alarm the manufacturer, and the propriety of making the crude iron in the North American colonies, where timber was plentiful, was proposed. Iron was first made in Virginia as early as 1619.

The production of crude iron was encouraged by the mother-country, but her children were not allowed to manufacture it. A heavy penalty was laid on those who erected "slitting mills," steel mills, foundries, &c., and laws were passed at a later period prohibiting the exportation of machinery or expert mechanics from England. Thus, England at that early day encouraged the importation of raw material, as she has done ever since, when she could not produce the article herself. But as soon as the manufacturers of England discovered that wrought iron as well as cast iron could be produced with pit-coal, and the fear of exhausted forests no more troubled them, the importation of pig-iron was prohibited by heavy tariffs. Only the superior Swedish and Russian bar was imported to any amount, because this class of iron could not then be made in England.

England, however, had no competitor. No other European country did or could produce common iron cheaper than herself, and she gave the colonies no opportunity to do so.

The amount of pig-iron exported to England by the Colonies from 1728 to 1768 was about 75,000 tons, of which 26,000 were exported from 1761 to 1768. Virginia could compete with England in the manufacture of iron, if she had not been *coerced* by the mother-country, who dictated what she should do, and what she should not do. Virginia, in consequence, with all her mineral resources, degenerated into a mere agriculturist, and a breeder of slaves.

But up to the time of Elizabeth, or, we may say, of Cromwell, England pursued no fixed policy in regard to her manufactures. The emancipation of her bone and sinew by the Reformation, and the assertion of the rights of the people under the Protector, developed the protective policy of England, and secured to her population not only

equal rights, but a prudent family government, which only sought for general good in England's aggrandizement.

Since then the rulers of Great Britain have not consulted the benefit or universal good of the world as the results from their policy, but how to make England rich, prosperous, and powerful; and they have succeeded not only in this, but in conferring on the world at large tenfold the advantages which could have resulted had England continued barbarous or neglected her own vital interests.

The result of her policy has been to acquire wealth from every source, to become the manufacturer for the world, and to compel less powerful nations to become her customers. But she conferred benefits while exacting their tribute.

From the year 1075 to 1575, the population of Great Britain but little more than doubled itself in five hundred years; and from 1575 to 1750 the increase was less than one-third. But during the first half of the present century the population of the United Kingdom more than doubled itself, besides sending a constant stream of emigration to the United States, Canada, Australia, Africa, and other parts of the globe.

In 1816, at the close of the French War, the debt of Great Britain was $4,205,000,000, and her estimated wealth $10,500,000,000. Since then, the increase of her wealth has been rapid, and may now be stated at nearly $100,000,000,000.

She has not only so vastly increased her wealth, but her ability to produce has been proportionally increased. In 1688 her population was less than 6,000,000, and the industrial or productive power of these were limited to the able-bodied men and women, boys and girls, who exerted only their brute strength, with but little assistance from intelligence, mechanical skill, or science. But in 1865 we find a population of over 30,000,000, whose average wealth is over $3000 per head, and whose productive ability is increased 20 times by the aid of labor-saving machinery; that is, the 30,000,000 inhabitants of Great Britain, aided by steam-power and mechanical skill, is equal to a physical force of 600,000,000 able-bodied men, or more productive power than is possessed by the entire manual labor of the world.

We need not say that China with her 340,000,000 can neither compete with the 30,000,000 of England in industrial resources or material power.

We cannot attribute this wonderful increase to her agricultural production or her extent, but must seek its cause in the prudent management of her domestic industry and political economy, her mechanical skill and constant protection to the production of her labor.

That little island, not larger than one of our great States, represents more available wealth than that of the world combined. She has conquered from savage and barbaric nations two great continents, and planted her children and established her language over an area of 12,000,000 square miles of the earth's surface, and reclaimed to civilization the best portions of the inhabitable globe.

That she has sought self-aggrandizement in all this we cannot deny; but the result has been a benefit to mankind. They who cannot help themselves cannot confer benefits on others. "Talents" that are hidden are not productive. To they who have most, more shall be given, simply because they earn it and deserve it. Wilful ignorance and folly are greater sins than "sharp bargaining" or the accumulation of wealth by far-seeing sagacity, even to the loss of others or at the expense of ignorance.

We can only blame ourselves, therefore, that England has, to the present time, profited more by our superior resources than ourselves, or that she has pocketed the annual products of our gold-mines. We pay her superior intelligence, skill, and sagacity nearly $100,000,000 per annum, all of which might be saved by putting in practice the policy of England,—to buy nothing we can make ourselves, to encourage no foreign trade which does not pay a profit, but to stimulate every manufacture and every commercial transaction which will realize profit and produce general prosperity.

During the early ages the arts and manufactures flourished in Asia and Africa. The Middle Ages transferred these industries to Europe; but England was neither first in wealth or power when Florence and Amsterdam were in their zenith of prosperity. She never would have acquired her present position had not her intelligence led to the practical development of her immense resources in coal and iron. Was she not the first to make use of the steam-engine, and create from coal, iron, and steam a laboring force equal to the physical strength of all the able-bodied men of the world? But even these advantages were not sufficient to the wonderful results which transformed the little island from heath and moor to a garden—from poverty to opulence—in the short period of a hundred years. Money, the machinery which puts all else in motion, was wanted, and this was provided by war, which has always been considered as calamitous and exhaustive; but, though long, bloody, and costly, it brought wealth to England. Paper money, which sophistical economists condemn, was the means of making gold plentiful in England. Her consols, representing her debt, gave her people the means of converting her stones of coal and rocks of iron into labor-saving machinery, and creating a productive industry which has rivalled the world.

RESOURCES AND POLICY OF THE UNION.

A few words will explain the colonial history of the Provinces under British rule. They were "drawers of water and hewers of wood" to England. They supplied her with such raw material as she could not produce at home, and opened markets for her manufactured goods at great profits. The surplus population of England is encouraged to migrate; to conquer new fields for her industry; and those peaceful conquests have been England's greatest victories. Her colonists in America were encouraged to spread over the continent, to invade the forests, and cultivate the fields, but they were not allowed to make their own axes or their own ploughs; they were told to grow silk, and wool, and cotton, and were offered premiums for raw material, but they were not allowed to make their own cloths or transport their own productions.

The quantity of iron made in this country was almost equal to that of England in 1740, when only 17,350 tons were produced; and our exportation of pig-iron to England during that year was 2275 tons.

Had our manufacturing interests been fostered and encouraged from that date as the manufacturing industry of England was, we should long ago have been able to cope with England and open our ports to *free trade* without injury to our own productive labor.

During the Revolutionary War we prospered and increased in wealth notwithstanding the long struggle; but when England lost the control of her disobedient offspring, she prohibited the exportation or migration of machinery or mechanical experts, and sought thus to retard the spread of the manufacturing interests, and to increase her own ability to supply the wants of the world at cheaper rates than it was possible for unskilled and unassisted labor to produce it. At this time the steam-engines of Watts and Bolton were fast coming into use, giving England the means of multiplying her productive power to an almost unlimited extent, and, as we have seen, have since increased her physical force from a mere fraction to 600,000,000 of units of labor. Her ability, therefore, to control the trade of the world is constantly increasing, and no other country save our own can ever become her serious rival in the manufacture of iron in its various shapes. Of the 10,000 square miles of productive coal-area in Europe, the United Kingdom contains over half, though its entire area is only 121,000 square miles against the 3,757,209 square miles of Europe. But, as compared with the productive coal-area of the United States, England's resources in this most important of all minerals to a manufacturing people are less in comparison than those of Europe

as compared with hers. Her 121,000 square miles of territory contain about 6000 square miles of coal-area. Our 3,000,000 contain over 200,000 square miles of coal. England has one square mile of coal for twenty of territory. We have one square mile of coal for every fifteen of territory; and, as we have shown, our resources in iron are equal to our resources in coal. England's contracted area neither supplies her laborers with food nor offers her products a market. She must, therefore, transport her supplies from beyond the seas, and ship the products of her mills and shops to foreign markets. We have an unlimited area: our plains and fields are on the same scale of magnificence with our resources in coal and iron. The products of our soil will abundantly clothe and support us; while the extent of our country and the diversity of our productions and wants offer our manufactures a home market far greater than the foreign markets ever enjoyed by England. If we had not a pound of domestic or surplus products to export beyond the amount of our imports, we should grow rich rapidly under the protective policy pursued so successfully by England, by the increase of our domestic wealth and the vast accumulation of the precious metals from our Western mines.

The development of our resources has been materially controlled and checked by the overwhelming productive power of England and her ability to produce cheap goods; by her policy of drawing the raw material from all parts of the world and returning the manufactured article, and by working up her own raw material into the most valuable forms. Her statesmen and her manufacturers have worked in harmony, because her manufacturing interests overshadowed all others. Her political economists have taught precepts which her lawgivers did not practise. They advocate *free trade* now, in certain articles when no other nation can compete with England in these productions. England by the use of labor-saving machinery increases the production of her work-people one hundredfold, and until other nations can approximate this result, free trade will result to her advantage. Cheap labor has comparatively little to do with this result. True, had the Chinese the same intelligence, skill, capital, and machinery, with the same resources, their dense population, laboring at sixpence per day, could even undersell England. But England, with all these advantages at command, and her able-bodied men working at fifty cents per day, can always undersell our manufacturers as long as they pay from one to two dollars per day for labor. Our people can never enjoy prosperity or a proper remuneration for their labor as long as the mere physical force is at open competition with the labor-saving machinery of Europe. But the United States, as before mentioned, can not only compete with England under the same development; but we are the only other country which can compete with her in the manufactory of the chief staples of the world. Notwithstanding our superiority in resources, however, we can never compete with her 83,000,000 horse-power of labor-saving machinery until we increase the physical force of each laboring unit in the same proportion, say one hundredfold. When this is done, and each million of our ingenious mechanics and experts shall have been increased one hundred million, then we shall be prepared to advocate *free trade*. But England will never permit this grand consummation, this magnificent development, as long as we allow her to cripple every attempt by exposing our manufacturers to competition and ruin every decade as a chronic political distemper.

But, under the degree of development attainable in this country through adequate protection for a short time, our skilful mechanics and ingenious inventors, whose productions are unrivalled, would soon add to our industrial resources that power in which we are now deficient to compete with England in our own markets; and every horse-power of steam machinery built and put in use at home adds to that ability by giving us a force equal to the labor of seven men, which can be exerted here as cheap as it can be in England, or put in competition with the meanest slave,—the most ill-paid labor of the world on the score of economy.

PROTECTION *vs.* FREE TRADE.

Having noticed why England is able to undersell us in our own markets, and that she can cripple the manufacturer of any nation not aided by labor-saving machinery, without regard to the cheapness of labor, we may now show how our policy has been framed to advance her interests more than our own, and to enrich foreign manufacturers while we have crippled or ruined those at home; that our superior resources and monopoly of productions in certain staples have enriched England without adding materially to our own wealth.

A brief history of our tariffs and their consequences will give the facts, and prove the necessity of protection for the development of our resources.

The Revolution ended British rule and legislation over the Colonies and their trade. That was the cause; this was the effect. The markets for our pig iron cut off, and the importation of British iron and manufactures suspended, our capital and skill were turned to supply our own necessities; and many small iron-works and factories were then called into existence to be crushed with the return of peace.

England clearly foresaw a dangerous rival in the American States. Their skill and superior iron enabled them to produce a better article from this material than could be produced in England. But the great improvements made in the process of manufacturing iron, and the use of *coal* and *coke* in its production, enabled the English manufacturer to produce a cheap if not a good article; and in order to control as much foreign trade as possible, the Act of 1785 (25 Geo. III. c. 67) was passed, to prevent, under severe penalties, the emigration of mechanics or skilful workers in iron or steel, or the exportation of any tool, engine, or machine, beyond the seas.

With the return of peace following the Revolution came an almost total drain of specie for foreign goods, and a languishing state of our own manufactures,—poverty, ruin, and low prices for labor and the productions of labor; proving that FREE TRADE brought even more ills than WAR.

FIRST TARIFF.

This state of things called the Convention and forced it to give power to Congress to protect our national industry. This produced the first American tariff, in 1789, which gave especial protection to our iron manufactures. When *they* suffer, every branch of industry suffers more or less. In 1791 our iron manufactures were in a prosperous condition and were profitably operated. The affairs of the country were in a flourishing condition. The tariff on rolled iron and steel and all the manufactures of iron except hardware was in 1794 fixed at 15 per cent. when imported in American vessels, with an addition of 10 per cent. when in foreign bottoms. These rates were retained until 1816. The War of 1812, gave a great impulse to our manufactures; but they were again depressed and rendered almost inactive at its close from the inadequate protection then afforded to the high prices of the war and the constant improvement going forward in the English manufactures and the consequent reduction in prices.

So great was the importation of foreign goods which followed the peace that during the first three-quarters of 1815 the value of our imports amounted to $83,000,000, and during the fiscal year next ensuing $155,250,000 were imported, which were paid for principally in specie and *notes at interest!*

The English manufacturers at this stage of our history made great sacrifices in order to control our trade and break down our manufactures. Lord Brougham said in Parliament that "it was even worth while to incur a loss upon the first exportation, in order, by the glut, to stifle in the cradle these rising manufactures in the United States which the war had forced into existence contrary to the natural course of things." These ex-

cessive importations were fraught with the most disastrous consequences. To our manufactures they brought ruin. Goods of all kinds, as well as labor, took a sudden and ruinous fall, and our experts and laborers were driven, in consequence, to other and new fields of labor. Most of them turned to the soil for support; but the farmers, like the manufacturers, suffered. The home-market cut off, reduced the price of their products to a comparatively greater extent than the reduction in the price of manufactured articles.

The national finances were in a deplorable condition, while our domestic industry was almost crushed out. The public debt was $123,016,375, and the annual revenues demanded by the Government was $24,000,000, and entirely beyond our means.

Necessity compelled an advance in the duties, and the amended Act of 1816 resulted; but the duties were so unequally laid that they produced more than double the requirements of the Government, without giving much protection to our manufactures, since the excess of imports continued. In 1818 the imports continued large, and amounted during that year to $121,750,000, against $73,854,437 of exports, which is greater than the exports of any other year previous to 1833. The drain of specie was consequently very great. The ports of Boston and Salem alone exported $5,000,000 within the twelve months.

FIRST CRISIS.

In 1819 the crisis came, as the inevitable consequence of a constant drain of specie to pay for the excess of importation. The Bank of the United States had been compelled to import specie in the first sixteen months of its operations, to the amount of $7,250,000, at a cost of over $500,000; while merchants paid a high premium for gold and silver to pay for the excess of their importations. Our manufacturers ruined, our workshops closed, our money exhausted, then came the natural decline of labor and the value of our exports, since Europe cannot sell cheap goods and pay high prices for food and raw material; and the result was not only disastrous to the manufacturers, but to the merchant and the agriculturist. A general paralysis now fell upon all branches of industry; and for the distress which followed, no alleviation was found until the return to semi-protective duties in 1824. The banks suffered from a lack of specie, and bankruptcies overwhelmed both the merchant and shipping interests. Merchandise could not be sold, and ships found nothing to carry. Farms were mortgaged, or sold at half their value; workshops and factories everywhere closed; manufacturers were forced to abandon their pursuits and sink their capital, while their experts were scattered, and forced to enter into competition with the farmer, and swell the products of the soil, for which there was no longer a market.

During 1822 our iron manufacturers were silent. The highest price of common bar-iron from 1820 to 1824 was forty-six dollars, and the average price about forty-two per ton. The importation of iron during this year from Great Britain was 15,000 tons,—a small amount from a present point of view, but an excessively large one then, almost before railroads came into existence. The imports were excessive in all manufactured articles; and while the duties were in excess of the requirements of the Government, they were not sufficient to protect our domestic industry, from which not only had the life been crushed, but even the spirit of enterprise had departed from our people.

The grain-producing capacities of the country had been increased five to six fold since 1790; but the exports of provisions were not greater than they were during the five years of protection from 1790 to 1795! While foreign nations supplied us with *cheap* iron, &c., they did not want even our *cheap* flour, beef, and pork.

The great argument of *free trade* is, that duties enhance the prices to consumers, and "buy where you can buy cheapest" is its creed. The question of markets, or how we may sell, is entirely ignored. The fact that the ability to buy depends on our success in selling is lost sight of, though thousands of examples have taught us that

bankruptcy invariably results from over-trading. We shall see, however, in the sequel, that we not only sell our staples cheap, but buy our goods dear, under the charm of *free trade;* not only because goods are dear at a shilling a yard when corn commands but ten cents a bushel, but because the price of foreign manufactured goods always *advances* as our own ability to produce them *decreases.* Let cotton cloth be an instance. That branch of our industry was inadvertently protected; its manufacture was encouraged, profits resulted; improvements introduced; capital increased; and in 1823, when the prices of all foreign manufactures were low, cotton cloth was made in this country with profit, while almost every other branch of industry languished. Protection enabled the poor man and the farmer to obtain his coarse cotton at half their former prices, while it supplied our people with employment, and gave a profitable home market in the community in which the manufactures existed. If such was the result in cotton, why not in every other staple article,—particularly iron, by which and through which every other branch of industry thrives?

TARIFFS OF 1824-28.

In 1824, protection to our domestic industry was again forced on the country by necessity. The manufactures of the country were disintegrating under the process of foreign rivalry, our people were reduced to the standard of foreign labor, with which they were forced to compete; and not only were they compelled by *free trade* to the status of the starving and crowded millions of Europe, from which they had endeavored to escape by emigration, but they were forced to pit their *bone* and *muscle* against the steam-engines and labor-saving machinery of England.

During the semi-free-trade period, from 1816 to 1824, the public finances had been so much reduced as to compel a resort to loans in a time of peace to save the credit of the country; while our agriculture and commerce suffered from the same causes which dried up the sources of both public and private revenue.

The total value of dutiable imports during the four years ending with 1824 were $264,962,457, and the duties thereon, $90,430,612, being an average of thirty-five per cent. The new tariff enacted in 1824 raised the average rate of duty to forty and a half per cent., which yielded during the next four years $121,637,942 on an importation of $301,558,885. But this increase in duty, though we should now consider it high, and which was, in fact, adequate to the protection of established branches of domestic manufactures, was not sufficient to resuscitate the dead spirit of our ruined industry. Let us notice woollen goods, for example, the duties on which had been increased from twenty-five to thirty-three and one-third per cent.; and on the strength of this increase, woollen manufacturers started their mills, and new mills were erected; but as soon as this duty on imported woollen goods went into operation, Great Britain reduced the duty upon foreign wool from sixpence to a halfpenny per pound, for the acknowledged purpose of enabling her woollen manufacturers to retain and control the woollen trade of the United States.

The cheap labor and labor-saving machinery of England, her long-established factories, great improvements, and vast capital, proved too much for our domestic manufactures, notwithstanding this high duty. Absolute prohibition was required to resuscitate our manufactures, or bring into existence new branches of industry, open to European competition. From this absolute want sprang the highly protective and almost prohibitory tariff of 1828, which resulted in "good times," high prices for labor and the products of labor, and both public and private prosperity, not only North, but South.

The planting interests of the South, however, always blind to an enlightened policy, and governed by short-sighted and selfish motives, remonstrated against the Tariff Act of 1828 as "unjust, oppressive, and unconstitutional." They were willing to pay

tribute to England, but they were not willing to advance the best interests of their common country by bearing a temporary ill to prevent permanent disease,—a disease which has since nearly resulted in disruption, and which has been only cured by the most severe suffering, the most cruel treatment.

South Carolina—always poor, little, discontented, and miserable—passed her famous *Nullification* Act in 1832; but President Jackson's "hemp remedy" then produced better results than President Buchanan's "cordial" since. In the face, however, of Southern arrogance, ignorance, and croaking, the country prospered; the public debt was paid, principal and interest; manufactures flourished; and many of our most profitable branches of domestic industry were then firmly established,—enabling us to compete with England in her own markets for the peculiar goods whose manufacturing had been encouraged.

The continual hue and cry from the South, coming from those who were anxious to sell the English a pound of cotton for a shilling and buy back an ounce at twenty-five cents, who racked their generous soils and permanently impoverished the inheritance for a "mess of pottage,"—a few paltry dollars to spend in idleness and selfish luxury, —at length overcame the prudence of our statesmen, and led them to commit the fatal error of repudiating the "American system," and dwarfing the growth of our manufactures, which, otherwise, to-day might have been able to compete with the world.

THE COMPROMISE ACT.

In 1833 the celebrated *Compromise Act* became a law, and reduced the duties on imported goods about one-half. The effects of this reduction were not immediately felt. The change from abundance to famine is gradual; *want* comes when *waste* stops from exhaustion. Our surplus supported us for a time, but we lived on our capital rather than its profits. This could not last long, and from plenty we were again plunged into poverty and general distress.

In 1836 the importation amounted to $189,980,035, or an increase of $63,458,703 over those of 1834, the first year of the Compromise tariff, with an average, for the three ears ending in 1837, of $155,465,703 per annum. These excessive importations again rained the country of specie and drove capital from the manufacturing to the agri- ultural interests, and the result again came in *ruin* to many and loss to all. The econd crisis commenced on the 10th of May, 1837, by the suspension of the New York anks, followed by the banks throughout the Union. Importation—which still amounted o about $141,000,000, or $23,500,000 in excess of the exports—declined $48,000,000, ecause we were drained, bankrupt, and could not buy more or make the ruin greater. 'he nation again became a borrower to save its credit. Bankrupt laws obliterated idebtedness, and financial troubles ensued which even to this day leave their marks.

Thus we see the cause and effect. There is no speculation about it. History shows in such clear and prominent letters that "he who runs may read." Protection to omestic industry brought prosperity; free trade brought adversity. The laws govern- g those results are as immutable as the laws of society, and no more. We cannot long ntinue to spend more than we earn, or to buy more than we sell, unless we reverse r usual course, and instead of "selling rabbit-skins for a sixpence and buying back eir tails at a shilling," try to play that game on others.

TARIFF OF 1842.

The free-trade tariffs have always been experiments, and they always resulted disas- ously; while our protective, or semi-protective, tariffs have always been forced on us stern necessity: yet they always resulted in plenty and prosperity, *wealth*, *growth*, d *power;* while *free trade* brought *crash*, *crisis*, and *ruin*.

The Government was again compelled to advance the duties, and in 1842, notwithstanding the Compromise Act, which was considered as binding between the North and South, Congress passed the protective tariff of that year. It was the result of an emergency, yet was proposed as a prudent and wise act of legislation for the general interests of the country, and the effects were almost magical.

"In 1842 the quantity of iron produced in the country but little exceeded 200,000 tons; by 1846 it had grown to an amount exceeding 800,000 tons. In 1842 the coal sent to market was but 1,000,250 tons; in 1847 it exceeded 3,000,000 tons. The cotton and woollen manufactures—and manufactures of every kind, indeed—grew with great rapidity; and thus was made everywhere a demand for food, cotton, wool, tobacco, and all the products of the field, the consequences of which were seen in the fact that prices everywhere rose, that money became everywhere abundant, that farmers and property-holders generally were enabled to pay off their mortgages, that sheriffs' sales almost ceased, and that the rich ceased to be made richer at the expense of the poor."*

AD VALOREM.

But this prosperity continued for a short season only. The National Treasury was too full; money too plentiful; the tariff was too good; and "tinkering" and experiment was again resorted to by our statesmen. It is said, however, that the "lobby" and British gold framed the tariff of 1846–47 and its *ad valorem* duties. The duties of 1842 were specific, and were collected on our own valuation in cash, and the appraisers, collectors, and naval officers had power to examine parties under oath in relation to the value of exported articles in the principal markets from whence they were exported. But the tariff of 1846 gave to importers the means of peculation and fraud by obtaining false invoices; and while the duties were not sufficient to protect our domestic industry, they were still made less protective by the dishonesty of the British manufacturers and their agents here.

But a still more powerful influence rendered our domestic manufacturers less able than usual to compete with the foreigner at this time. The highly protective duties of 1842 were almost prohibitory in many articles of importation. Our industry flourished in consequence; the prices of labor and the products of labor were high; money was plentiful, and the markets for home production insatiate.

In England the case was reversed. The United States were her best customers during the free-trade periods; and when these were cut off by high tariffs the prices of labor and the productions of labor there were cheap. Consequently, the English manufacturers were able to sell their productions much below American prices, which were then unusually high. English labor cost fifty cents per day, ours not less than one dollar and fifty cents, or three times the price of English labor; while the freights from England to New York were not greater than the transportation from our manufactures generally to the same point. Our labor, therefore, should drop suddenly to the English standard if we would compete with them. But revolutions of this kind cannot be effected in a day or a year. Prices and regulations cannot change so suddenly. Bankruptcy and ruin come to communities slowly. Foreign goods sell cheap at first, when we are rich, but dear at last, when we are poor. These are natural results; but British policy encourages them, and British avarice hastens to take all the advantages they offer.

It is strange that statesmen, with our history before them, and the examples of former years fresh in their memory, should legislate for the destruction of domestic industry and in favor of our foreign rivals. The disastrous results of a free-trade policy had

* Henry C. Carey.

been demonstrated again and again. Ruin always followed in its wake; while protection always brought prosperity, "good times," and high prices for labor and the products of labor. Yet, strange as it may appear, we were again to try the "blessings of free trade" as taught by British economists. We were to experience once more the beautiful precepts so lovingly taught us by our good cousins over the water; but we ignored their example. The free-trade tariff of 1846–47 took the place of the protective tariff of 1842. When this free-trade tariff went into effect, we were rich; plenty everywhere existed; our vaults were full of gold, and our people enjoyed prosperity and abundance. All this could not change suddenly. Our wealth did not vanish in a day nor a year. But a *crisis* was imminent in 1850. The gold of California only put it off. In 1852–53 we exported $97,000,000 in specie to pay for goods which we should have made ourselves. But the treasure of California, though it flowed in a steady stream of millions from the Golden Gate of the West, only put off the evil day by paying the enormous losses of our free-trade hobby. In 1857 came the third crisis, and we were poor indeed. The profits of former industry, the millions of California, the labor of many years, all wasted by the insatiate demands of free trade, or, worse, gone into the pockets of our enemies and rivals.

This crisis came, perhaps, at the proper moment, since it was necessary to shape the public sentiment in proper form for the great results which were to follow. It left us poor,—our factories closed, our manufacturers ruined, our experts scattered; but it taught our people wisdom, and prepared their minds for the advent of the slaveholders' rebellion,—though their pockets and their means of defence were sadly deficient in consequence. In 1860–61 came a change in political parties and political economy. "Protection to our manufactures was accepted as protection to our farmers," and adopted as a plank in the Republican Platform.

"Better reform late than never." But let us see how great the emergency, how necessary the change from free trade to something like protection, and how illy prepared we were, in consequence of ten years of the "crushing-out" process, to meet the gigantic demands which the war so suddenly forced upon us,—how indispensable those manufactures which we refused to protect in peace were to our protection in war.

In 1849 and 1850, the quantity of English railroad iron rushed into American markets were 200,000 tons, at $40 per ton, to which low price we had forced it during our season of protection. Our mills, which produced 41,000 tons annually, and were then capable of producing 70,000 tons, were reduced to 16,500 tons average during these years.

The furnaces went out of blast, because the market for pig-iron was destroyed by the stopping of the mills. Under these circumstances, in order to save themselves from actual ruin, our manufacturers asked simply for protection against actual loss, or enough to allow them $50 per ton for iron which was one-third more valuable than English iron; but Congress refused to help them; they permitted our foreign rivals to crush out competition. Our productions fell from 800,000 tons of pig-iron per annum to less than 500,000 tons, instead of increasing as formerly. England then stepped in for our trade, and before competition could be again restored, the price of iron went up from $40 to $80 per ton! At enormous prices, England supplied us with no less than 1,000,000 tons of rails in the four years 1851–54.

The additional price paid during those four years by our railroad companies as a penalty for permitting American competition to be crushed out, could not be less than $30,000,000, which went into British pockets. This crushing-out process culminated with the crisis of 1857, and left our factories closed, our workshops idle, our furnaces out of blast, our mills deserted, our exports scattered, our capital sunk, our credit destroyed, our iron industry crippled, and the munitions of war consequently unavailable.

This was our condition on the breaking out of the rebellion, though we had been for a whole decade in possession of mines of treasure that yielded us more than $500,000,000!

all of which had gone to Europe, without enabling us to pay our way, or make up for the annual loss of our free-trade experiment; while we owed not less than $500,000,000 in addition to English or European capitalists, on which we could scarcely pay the interest, and our credit was so low that our bonds found no further purchasers. So much for free trade! These are its lessons. Will we never profit by our sad experience?

"THE PROTECTION OF WAR."

The limited tariff of 1861 could not have had the effect of suddenly starting our factories and reviving our industry to the astonishing extent we have witnessed during the past three years. In 1812, the demands and "protection" of war revived our industry, and brought wealth and prosperity. In 1861, and during four years of the most costly and tremendous war the world has ever known, we have increased in numbers, wealth, and general prosperity. Our losses in treasure were and are greater under the demands of free trade than under those of war. We can better afford to pay $2,000,000 per day to our soldiers and manufacturers at home to *protect* our domestic industry, than we can to pay England to do our manufacturing in iron alone. We can better afford to pay the interest on $3,000,000,000 to our own people on our own capital, than to pay the balance of free trade to Europe! The first is accumulative, while the second is exhaustive.

During the war, our production of pig-iron increased to 1,300,000 tons, and, with protection, it can be made to double itself every five years, with an annual decrease in cost. Our rolling-mills produced 283,560 tons of rails in 1864, and possess a capacity of 700,000 tons per annum of rolled iron.

The protection afforded by the war has now partially ceased, and that given by the tariff of 1861 is rendered ineffectual in some cases by the operation of direct taxes, particularly on our iron manufactures. The Republican party pledged themselves to give "protection to the farmer by bringing the consumer to his side;" but we find the reverse to be true at present, and free trade virtually rules to-day over many important branches of our domestic industry.

The duty on iron is nominally $15.68 per ton of 2240 pounds. The direct taxes paid by the manufacturer are $8.40 per gross ton, and the indirect taxes $7.83,—making a total of $16.23 paid by the iron manufacturers on a ton of rails, or 55 cents excess of tax over duty.* The only protection now afforded is in the premium on gold, which we cannot wish to continue. We are, therefore, to-day, though under a Government pledge to protection, on the road to crash, crisis, and ruin, which is sure to follow free trade.

Our exports for the first ten months of the present calendar year—1865—were valued at $86,500,000 in specie, while our imports for the same time amount to $168,500,000 in specie!—or an excess of $82,000,000!!—which must be paid for in gold, or, worse, in Government bonds, bearing interest, of which over $1,000,000 go to Europe every week. *It is known that* more than $500,000,000 of railroad and State bonds are held in Europe, on which the highest rates of interest are paid, and it is feared that over $500,000,000 Government bonds have already found their way to the same hands.

We presume that a direct loss has been suffered in this last transaction of at least $250,500,000. Many of these bonds were sold at a discount of 150, and none less than 40 per cent.; an average, therefore, of 50 per cent. is less than that which has been paid. For this $250,000,000 we have nothing to show; and yet the interest is entailed, because we have absorbed the capital in excess of imports.

We can far better afford to war with all Europe, year after year, than give her free

* Letter of Daniel J. Morrell, Esq., to the Secretary of the American Iron and Steel Association.

trade, the best of our markets, and pay the balance of "profit and loss" in bonds at 46 per cent. discount.

Ten years of such intercourse would lead us to irreparable ruin,—repudiation,—while ten years of war with all Europe would afford us full protection, wipe out our debts, and save us an annual drain of specie which, under free trade, would not be less than $100,000,000 per annum. Could we not far better pay $2,000,000 per day to our own soldiers, and those who furnish army and navy supplies, to afford us the "protection of war," rather than pay an annual loss so enormous, so ruinous? The taxes paid to our government is not a loss to the country. It passes from hand to hand, and rather increases than diminishes the wealth of the people, since it is paid principally on capital furnished by the government, on which we realize a profit after paying the interest. But we can far better afford to pay and keep in the field 500,000 soldiers than allow the domestic industry of 30,000,000 to languish, and pay Europe to work for us. We had better tax the industry of the country $2,000,000 per day, than lose a larger amount by idleness, and the want of profitable employment, by crushing out the spirit of industry by free trade!

THE WEALTH OF NATIONS.

Having presented a brief résumé of our tariff Acts and their results,—showing the evils of the one and the benefits of the other, as demonstrated in protective and free-trade tariffs,—we now offer a concise and practical illustration of the ways and means to national prosperity, or in what consists the wealth of nations.

A nation's wealth consists principally in her natural resources; secondly, in the intelligence, skill, and industry of her people. A country may be rich in all the bountiful gifts of nature, as Mexico and China, and yet without the ability to profit for the lack of intelligence, skill, and industry. We find the people of New England, who have not much to boast of in their barren hills, far more wealthy and prosperous than those of Virginia, who for centuries have been delving in miserable poverty among the untold riches of a most magnificent country.

England possesses both in an eminent degree, and prospers wonderfully by their combination. She has more available coal than exists in all other parts of Europe, and perhaps her iron and tin and copper are on a corresponding scale. She certainly makes the best use of them.

Her intelligence taught the use and value of iron, and her people were the first to make it on the grand scale, with mineral coal for fuel,—first in the blast-furnace for the production of cast iron, then in the puddling-furnace for the elaboration of the bar. Skill and industry were the handmaids of science. What the intelligent mind proposed, the willing hand did skillfully. This knowledge brought her power and wealth. Steam obeyed the ingenious Watts, and strong, tireless motors of iron, breathing fire and steam, sprang forth, full-grown, like Minerva from the brain of Jupiter, to labor for the intelligent Englishman.

While the people of the South bought slaves of flesh and blood,—men and women, with all the failings and ills of humanity,—and drove them to the fields under the lash of the taskmaster, the people of both Old and New England bought or made the tireless "iron slave,"—the steam-engine,—which, directed by intelligence and skill, was a hundredfold more valuable to the owner or master than the negro slave. The price of the latter, say $1000, bought *seventy times* the power in the former. Each horse-power, costing one hundred dollars, does the work of seven men while employed; but since human limbs grow tired and the iron wheels do not, we may say that each horse-power, directed by intelligence, is worth ten ignorant negro slaves.

The slave-masters of the South owned 4,000,000 of the latter, while the manufacturers of England owned 83,000,000 of the former.

The planters of the South followed the rude and primitive pursuits of barbarous ages, and supplied with slave labor the *more skilful* spinning jennies of England with the raw material at six cents per pound, and bought it back again in manufactured articles at ten times its former value. The barbarous slave paying tribute to the civilizing iron! England's slaves need no lash, but work patiently, tirelessly, and most effectively. In peace, industrious and accumulating wealth; in war, formidable, and the first to hurl forth wrath on the foe. They need no emancipation; with them no insurrection is feared.

Ignorance may import coolies or buy or breed the negro slave, but intelligence will build the steam-engine.

The slaves of the South brought poverty, waste, war, and desolation, and never did, and never could, have made their masters powerful, influential, and wealthy. They were an element of weakness,—a relic of the barbarous past.

The steam-power of England has enabled her to increase the productive ability of her 30,000,000 intelligent and industrious people to 600,000,000 of laboring units, as before stated, each equal to the physical force of an able-bodied man. This acquisition of mechanical power has enabled her to manufacture for the world, to gather wealth from every quarter of the globe, and spread her language, her influence and power in every clime. She has founded a mighty nation in the West, destined to overshadow her in future greatness and wealth. But, while we are passing out of her power, she is creating a new nation of perhaps equal magnificence on the remote continent of Australia, where a wide field is open for her surplus population and future markets for her products.

The labor and labor-saving machinery of England has enabled her to multiply her productive ability. They constitute an element of her wealth; her furnaces, mills, mines, railroads, ships, &c. &c. add to her means of production, while her capital in bonds, notes, gold and silver, enables her to transact vast business operations and effect exchanges which result always to her profit. Her prudence, intelligence, skill, and industry are, therefore, aided by the natural and artificial means which they have utilized. Her wealth, therefore, consists in her property. But the value of her possessions depend more on their utility or her management of them than on their cost. Her engines would be valueless and her ships would be a burden were they not profitably employed. The aim of her capitalists and statesmen, therefore, has been to make every thing pay. Sectional or selfish interests are not tolerated when they conflict with the public prosperity. Her tariff permits no importations to injure her domestic industry. If she proclaims free trade in bread-stuffs, cotton, and iron, is it not to her interest to do so? Her operatives can make more in spinning cotton and making cloth than in cultivating the barren heath or the swampy moor; while no other nations can compete with her in the manufacture of iron. But she does not allow the smart Yankees of New England to send her pins, screws, locks, or clocks duty free, nor do the fine manufactures of France compete with the broadcloth of England.

Her statesmen have been wiser than ours. With them the question is not how to raise the means to keep the machinery of government moving, but to increase the wealth and prosperity of the nation. "Will it pay?" seems to be the first consideration of every tariff act and every treaty; and so far they have made few mistakes. Every ton of coal and every pound of iron dug from her extensive mines has paid a profit. Every bale of cotton and every pound of wool which she has imported has added to her vast wealth. Her ships carry for the world, and the world pays roundly for it; and as long as she continues to give her vast labor-saving machinery profitable employment

by finding profitable markets, so long will her wealth increase. But should her markets fail and her ships lie idle, England's wealth will be sadly depreciated

The prosperity of nations is, therefore, much like that of individuals. Industry and prudent management are almost sure to accumulate; while idleness and ignorance or folly are sure to lead to ruin. The want of profitable employment is a misfortune.

The condition of the American people is widely different from that of the English. Their manufactures came into existence without opposition, because they led the world in improvements and were the first to put iron and steam into harness. Human thews could not compete with limbs and wheels of iron. We, on the contrary, were forced into competition with England under the most unfavorable circumstances. She controlled us, not only by superior manufacturing ability, but by prohibitory laws; and, while the only people on the earth whose natural resources are equal to competition, we have been her best customers, and have paid her, first and last, thousands of millions; though we have furnished her manufacturers more raw material than all the rest of the world combined.

Unlike England, we find our best markets at home. Our country is thirty times greater in extent than the island of Great Britain; our productions are more diversified. We produce the raw material, and can furnish food to any extent. Our people are as intelligent, our mechanics as skilful. Our natural wealth is also thirty times greater than hers, acre for acre, because our mineral resources are in excess. We have one square mile of coal for every fifteen of territory; she has one for every twenty of territory; while our resources in iron are equal in comparison. Our soils are naturally richer, and are capable of feeding the world. Our mountains produce gold, our fields are white with cotton, while every product of Europe finds a congenial climate here,—the grape of France, the silkworm of Italy, or the merino sheep of Spain.

With these unparalleled resources, intelligence, skill, and industry, why are we buying from Europe at this moment double the amount of our sales? Why are we spending double our income? Why are we so much in debt to England? Why is our vast natural wealth unavailable? Why do we go to England for iron, while we are thirty times richer in ores and coal than she is? Simply because we send our surplus capital to Europe for goods, instead of investing it in labor-saving machinery, railroads, mines, furnaces, and mills, and in creating and sustaining a domestic industry which would yield from ten to twenty per cent. If sent to Europe, our gold is lost to us; we receive no benefit, except in the temporary wear of a coat or a rail. But, if invested in machinery to produce the coat and the rail, we not only save their cost, but we have the means of reproduction. It becomes productive wealth. Had we manufactured all the iron we have purchased from England since the Revolution, we should not only have saved the $500,000,000, or perhaps double that amount, which we have spent for the purpose, but it would have been invested in labor-saving machinery, mills, furnaces, &c., which would net us at least ten per cent. profit and enable us to compete with England in the manufacture of iron.

At the period which we name, or during the Revolution, our ability to produce iron was greater than that of England, and the amount actually produced was not much less. Had we been protected by tariff, or *war*, ever since, against the cheap labor of Europe, the amount of iron consumed in this country would have been increased perhaps tenfold, and the prices reduced much below those which have ruled. We should long ago have substituted the steam-engine for the negro slave, and have saved blood as well as treasure by the exchange.

The wealth of England at the close of the Revolution was not one-tenth of its present proportion. Our wealth to-day may be stated at $20,000,000,000, inflated as all values are now; while that of England is $100,000,000,000, on a substantial basis. Our

$20,000,000,000, however, is not now productive. We are going in debt every day; while her $100,000,000,000 is constantly accumulating.

Our census returns show an average increase of over 8 per cent. per annum in the loyal States; but they also made the increase of wealth in the Southern States over 9 per cent. Was that real or productive wealth? If so, where is it now? The war cost the North more than it cost the South; yet war made us richer, while it made them poorer. Their wealth was not productive.

During the war we accumulated wealth, though we spent nearly $2,000,000 per day in sustaining our armies. To-day we are losing it in vain competition with the cheap labor of Europe. Then, every man not in the army was at work, with mind or limb, and thousands of steam-engines were laboring unceasingly. Now, hundreds of thousands are comparatively idle, and our steam-machinery finds scarce half employment. Ten years of free trade, such as we now suffer, would bring crash, crisis, and ruin, with repudiation and shame; while ten years of war with all Europe would wipe out our debts and make our natural resources available. But a protective tariff will secure by peaceful means better results than can be obtained by war.

Productive wealth does not, therefore, consist in fields of coal or mountains of ore, in bales of cotton or hundreds of thousands of slaves, but in our own ability to make them available and profitable. We may own $20,000,000,000 of inflated stock, but if it does not pay it is not wealth. Our furnaces, mines, mills, factories, and ships are not productive of wealth if they cannot supply our wants. We may mortgage them, as we are now doing, and live on the proceeds thus obtained for a season; but crisis and ruin come at last.

We cannot compete with the cheap labor of Europe, or the labor-saving machinery of England, unless our people will work for the starvation prices of the Old World; and even then we cannot do so without the assistance of steam and machinery.

The Irish in Ireland labor cheaper than the English in England, but they do not grow rich. Labor in Turkey, Hindostan, and South Carolina has always been lower than it has been in England, but can it compete? Japan is rich; her labor is cheap; but how long would it take England to fleece her, without protection to her industry?

It is scarcely possible to express the wealth of nations in a word; but by THRIFT it is acquired, with that knowledge which turns all it touches into gold. In this sense,

"Knowledge is Power." §

POLITICAL ECONOMY.

Political economy as a science embraces a wide range of subjects. We propose, however, to consider it practically, and only in its relation to our domestic industry and the development of our resources.

Free trade is very simple. Its name is attractive to a free people; and it would be very acceptable if all nations were governed by the same laws, the same interests, and the same habits. Even then, those having the most productive soils and the richest minerals would become wealthy at the expense of those who were deficient in natural resources. But since this is not and cannot be the condition of the world, political economy becomes a necessity. It protects the weak against the strong, the poor against the rich. It provides measures for the proper recompense of labor, the encouragement of industry, protects private enterprise and fosters public welfare. It should preserve for Americans the magnificent natural wealth of America. It should protect our industry from the labor-saving machinery and capital of England, and our people from the cheap labor of Europe. That is not economy which squanders the bountiful gifts of nature and neglects domestic thrift,—which advocates free trade, and consequently brings the

standard of free labor in America to the level of the starving millions of Europe. The great object of political economy should not be to encourage

CHEAP LABOR,

but to provide free men with a fair share of the profits of labor, and some benefits from the natural wealth of their country.

The cheap labor of Europe represents "coarse food, mean clothes and lodging, political nullity, ignorance, and serfdom," without encouragement or opportunity to rise above the condition of dependence and poverty.

The free labor of America represents an abundance of the best food, the clothing of a gentleman, a home of independence and domestic comfort, choice of occupation, participation in government, with inducements and opportunity to acquire wealth, honor, and position.

Free trade reduces American *free labor* to the standard of European *cheap labor;* but protection to our domestic industry, by a judicious economy, prevents the one and secures the other. It seems preposterous to argue so plain a matter as this. These facts are "self-evident." But the advocates of free trade advance the

FARMER AND THE PLANTER

as the first or principal producers of wealth, and those whose interests should be the first consulted. It is true, these are our great and vital interests at present, and these interests we are most anxious to serve. But how does free trade benefit the one or the other? How can we serve them, if we neglect the manufacturer and the mechanic?

We can have no home markets if we are all farmers and planters, and the manufacturers of Europe cannot buy more from us than they sell back to us. They have always bought less than they sold. If they buy a bale of cotton, they pay for it with a piece or bolt of cloth. If they want a barrel of flour, they send us a bar of iron. But if we had the manufacturer and the mechanic side by side with the farmer and the planter, we could obtain two bolts of cloth, or two pieces of calico, and two bars of iron, for the same price.

It is notorious that the protection of war has advanced cotton from six cents to fifty cents a pound; while we know that free trade reduced it from twenty-five cents to its lowest limit. Free trade reduced corn to ten cents or less per bushel, while protection advanced it to fifty cents and above.

That is not economy which robs the generous soil of all its richness in order that its productions may be sold cheap in foreign markets. Yet such has been the economy of the planter and farmer in this country. The soils of Virginia and the Carolinas are nearly exhausted, and yet the planters did not acquire wealth, though provided with the cheapest of labor, which only received coarse food and scanty raiment for its hire. The result is, exhausted lands and poverty-stricken people. The magnificent prairies of the West yield, year by year, less and less to the farmer, because their export trade pays but a scanty pittance for their labor, and returns nothing to the impoverished soil.

But, while free trade is racking the rich soils of the planting South and impoverishing the prairies of the farming West, the sterile hills of manufacturing New England are increasing in richness and production; while the soil of Great Britain, which cannot compare with those of the South and West in original yield, now produces from two- to three-fold greater crops. It is therefore evident that the farmers and planters are decreasing instead of increasing the national wealth, by exhausting the strength and consequently depreciating the value of the soils, and that free trade and foreign markets cannot return the wealth thus extracted. The conclusion is plain.

THE MINER, MANUFACTURER, AND MECHANIC must labor side by side, or in the same community with the planter and the farmer, if we wish to profit by our magnificent resources, increase in wealth, and keep step with the progress of intelligence and civilization.

The husbandmen and shepherds of the barbarous ages used their fingers for forks, and the skins of their flocks and herds for clothing; yet their Tubal-cains were forced to supply them with knives and instruments of brass. The savages of America depended on their rude mechanical skill in constructing snares and bows and arrows for their food, while the Hottentots of Africa owe their precarious and miserable existence more to their ingenuity than to the natural fruits of the earth.

The soil cannot be made to yield its fruit without some instrument of mechanical construction. The burned stick of the Indian, the wooden plough of the Roman, the rude coulter of our grandfathers or the steam cultivators of to-day, must be made use of.

We would relapse into barbarism without the aid of iron and those metals which subject all nature to our use and pleasure; but we cannot obtain them without the miner and the manufacturer nor can we fashion them to our wants without the skill of the mechanic.

Yet science and knowledge are quite as essential. The ancient manufacturer made ingots of steel, and the East Indian of to-day, blowing his fires through a sheep-skin bag, can produce a *half-pound* of metal per day! Science has increased the production to one hundred pounds. Our ancestors in England carried their coal, ore, and iron on the backs of women and asses in 1600; and fifty years ago the planters of Virginia *rolled* their hogsheads of tobacco from Danville to Richmond!* Steam now does the work with a thousandfold increase. It is thus manifest that the miner, manufacturer, and mechanic are not only useful to the planter and the farmer, but absolutely indispensable. They are the handmaids of science and skill. It is said that John Randolph of Roanoke wrote above his door,

"Let no mechanic enter here;"

and well, perhaps, that he wrote these words, or that the principle expressed existed in the slavemaster's heart, for the good of humanity and the emancipation of the slave: but alas for the blood they have shed, the desolation they have caused the unfortunate South!

The miner, manufacturer, and mechanic are not only absolutely necessary for the production of food and clothing, but they furnish the means of promoting intelligence and civilization, the necessities, comforts, pleasures, and luxuries of peace, and the implements of defence in war.

These facts are evident. It is manifest that the richest soils must become eventually exhausted and valueless, by continual drains on their resources, without recompense. A purely agricultural people, therefore, adds nothing to the permanent wealth of their country, while a combined manufacturing and agricultural community constantly grows rich. There are many examples; but let Virginia and Massachusetts stand in evidence. The former was naturally rich, but is now poor; the latter was naturally poor, but is now rich.

But a purely agricultural community, as we have shown, cannot exist to-day without the aid of the manufacturer; and, since the first cannot fail to grow poor without the direct aid of the second, it cannot be a question in political economy as to the relative advantages of using foreign or domestic productions.

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* This was a common method at that time. A pole was put through the hogshead, and left projecting at each end; to these ends were attached "tongues," to which oxen were harnessed: when the oxen pulled, the hogshead rolled, and the projecting ends acted as an axis.

The miner, manufacturer, and mechanic must labor side by side with the planter and the farmer, not only in order to obtain the best results and acquire wealth, but to save our natural resources from depreciation and eventual exhaustion.

The mineral resources of our country are equal to its agricultural; but the one cannot be profitably developed without the other, and domestic industry must be employed to accomplish the result.

If political economy, every-day examples, and reason, teach us these lessons, is it not strange that we have not profited by them? Is it not a matter of astonishment that American statesmen should have so long neglected American resources? Is it not absurd for our farmers and planters to advocate free trade, which not only tends to impoverish themselves, but their lands also?

The foregoing facts and arguments should be sufficient to convince intelligent men; but, since prejudice, party, and the sophistry of foreign economists, agents, and importers are arrayed against the truth, we will give a few plain and

PRACTICAL ILLUSTRATIONS.

The value of the cotton crop exported may be $190,000,000, but the value of the articles consumed by the producers to supply their wants would be greater. It is notorious that, while the few planters lived in ease and luxury, the "poor whites" and negroes, or over one-half the entire population, existed in extreme poverty. The price realized by their productions did not pay for the labor of producing; while their lands were constantly growing less productive.

In the mean time—say 1860—the people of New England bought cotton of the South to the amount of $37,680,782, which they sold for $79,359,900. To accomplish this, only 29,886 boys and men and 51,617 women and girls were employed, whose total wages amounted to $16,725,720, leaving a profit of $25,953,358, at the same time giving a valuable home market to their farmers, and enabling them to increase the productiveness and value of the soil by full compensation.

In the South, while less than 1,000,000 of slaves were raising cotton, not less than 2,000,000 were comparatively idle, or employed in no useful or productive pursuit, the planters doing nothing, and the *poor whites* either—worse—drinking whiskey, or earning a miserable existence from worn-out soil, or drudging in competition with the slave, whose pay was only coarse food and scanty raiment.

These 2,000,000 unproductive people, if directed by intelligence or the example of New England, could have manufactured the entire cotton crop of the South, and raised food enough to sustain both themselves and the cotton-producers. The profits would be thus not only equal to the value of the whole crop, but the enhanced value of the article in its manufactured state not less than $380,000,000,—independent of the amount sold to New England,—or double the value of the raw material.

The value of manufactured products in the Southern States in 1860 was $150,312,682, to produce which only 98,741 men and boys and 11,309 women and girls were employed; or 110,050 male and female operatives, as manufacturers, produced more than half the value of that produced by the 1,000,000 slaves employed in the culture of cotton.

A man may earn one dollar and fifty cents per day at his daily labor, and save half of it, if his wife and children will cultivate his garden and spin and weave their clothes. But another may earn two dollars per day, and be always in want and debt, if his family are idle and extravagant. The same with the farmer and the planter: if they buy more than they sell, or consume even as much as they raise, they must eventually end in bankruptcy, if not ruin; because, while they live within their means apparently, their lands become less and less productive, while their families become more and more expensive.

The farmer has coal and iron on his land. His sons can make, during leisure times, all his articles in the hardware line, and thus save him from fifty to one hundred dollars per annum. He can grow flax and raise wool, and his daughters can spin and weave most of his clothes, and thus save from $50 to $500 more.

This domestic economy or industry applies equally to nations; for the interests of communities are identical with those of families. When the imports exceed the exports, when gold flows out of the country, we are growing poor; but when the exports exceed the imports, and gold flows into the country, we are growing wealthy. During times of war or prohibitory tariffs, we may also grow rich by raising and manufacturing all we require, by the increase of our home markets, the growth of our domestic products, the addition of labor-saving machinery, the development of our mines, and the general appreciation of all values in consequence, without a dollar of exports.

The total value of our agricultural products, other than cotton, sugar, and rice, is now $3,000,000,000 annually. Our foreign markets consume of this amount only the trifling sum of $80,000,000, and often much less. Yet there are those who openly advocate free trade, in order to give the farmer a market! who would break down a manufacturing industry, which consumes over $2,000,000,000 annually, for the insignificant market of Great Britain. They would crush the coal and iron industry of this country, whose total product, in its various forms, amounts to $400,000,000 annually, 90 per cent. of which affords a home market to our farmers, for the miserable $20,000,000 consumed by England!

The total value of the manufactures of the United States for the year ending June 1, 1860, was not less than $1,900,000,000. The increase from 1850 to 1860 was 86 per cent., and we may safely estimate the increase since at 50 per cent., which would yield $2,850,000,000, or almost as much as the agricultural products. But this vast amount is exclusive of mechanical productions below the annual value of five hundred dollars, of which no official notice is taken in the census. Yet these small amounts are sufficient to swell the amount of our manufactures to over $3,000,000,000.

To produce the $1,900,000,000, as returned by the census of 1860, nearly 1,400,000 persons were employed; and, estimating their increase at 50 per cent., in proportion to the increase of production, the number of operatives now required is 2,100,000. These, on an average, support two and a half other persons as dependents, &c., making the whole number supported by our manufacturing industry 5,250,000, exclusive of that large class of "middle-men," such as merchants, clerks, draymen, railroaders, expressmen, and steamboat-hands, carpenters, masons, painters, &c. &c.

We may, therefore, estimate that fully one-third our population is supported directly, and two-thirds directly and indirectly, by manufacturing industry, since it gives a market to two-thirds of our agricultural productions. That interest, therefore, stands first in the political economy of the country. Yet there are those who consider the planting interests of the South as productive of the paramount staples of the country, and would ruin our manufacturers, who are increasing our wealth, to foster our planters, who are impoverishing the richest portion of our country. There were those who cried, "Cotton is king!" a short time ago; but they were not more mistaken than those who cry, "Corn is king!" to-day. Iron is the conqueror of nature, the civilizer and benefactor of mankind, and without its aid no nation can become wealthy, prosperous, and powerful.

Our 2,000,000 miners, manufacturers, and mechanics, however, did not produce $3,000,000,000* of manufactured goods unaided: steam and labor-saving machinery

* The total production of the country for 1865 is estimated by Dr. Elder at the value of $4,318,000,000, as the minimum amount, and our calculation, made without reference to his figures, may be too high; but we think his amount below the actual production. It does not, however, invalidate our arguments, or change their application; since about one-half of this amount represents domestic manufactures, and the other part agricultural productions, while most of the agricultural products are consumed by the manufacturers and their direct dependents, considering our farmers as indirectly dependent.

gave them material assistance. We have no means of ascertaining the amount of steam-power employed in these productions, but it is manifestly much less per head than in England.

In the anthracite coal regions of Pennsylvania the amount of steam-power is equal to two horse-power per head, which enables each hand to produce 500 tons of coal per annum, or $2500 per head at present valuation, which is one thousand dollars more than the average production of the country per capita. The steam-engines of Great Britain are stated as equal to 83,635,214 horse-power, which would give about three horse-power to each inhabitant, and, of course, a much greater number per head to her manufacturing classes. But if we estimate two horse-power per capita as the maximum made use of by our 2,000,000 manufacturers, we have a force equal to 28,000,000 strong men, and capable of doing much more work. Yet how insignificant is this, when compared to the steam-power of England!

CHEAP LABOR *vs.* FREE LABOR.

Our manufacturers can only compete with England when they have provided an equal steam-power to the hands employed, and when they can find American free labor at English prices,—which we hope may not happen until the millennium.

We have tried *cheap labor* long enough in the South, and have found by sad experience that it brings poverty and ruin instead of wealth and prosperity. We had 4,000,000 of slaves, whose labor we compelled with the whip and rewarded with the coarsest of food—corn meal and bacon—and the meanest of clothing only. Yet we impoverished the soil, held the poor in ignorance and vice, and, instead of advancing in intelligence, civilization, and wealth, that portion of our country, though naturally the richest part of our continent or the world, was relapsing into barbarism.

If we do not protect our labor against the capital, machinery, and low prices of Europe, we must come down to their standard. We may import $300,000,000 of cheap goods; but we also import cheap labor for our mechanics and farmers, because we cannot get seventy-five dollars per ton for our iron if English iron is selling in our markets for fifty dollars per ton; and we cannot make iron at fifty dollars per ton if we pay our miners, mechanics, and experts two dollars per day, while those of England receive only fifty cents per day!

If our miners, manufacturers, and mechanics, who buy $2,000,000,000 from our farmers, work cheap, they cannot pay high prices for their food. Will the American farmer, therefore, advocate free trade, in order to purchase a few cheap goods, when the result must, in the nature of things, force him to sell his crops cheap? or will he sacrifice a profitable home market of $2,000,000,000 where free American labor at two dollars per day is the buyer, for an unprofitable foreign market of $80,000,000, where cheap European labor at fifty cents per day is the only customer? But there is another important consideration here. The foreign markets for breadstuffs and food generally fluctuate independently of the regulations of trade, and depend more on the *wants* of Europe than the prices of food. They only buy when short crops compel them, and only come to us for that which the agricultural portions of the Old World cannot supply them. Our farmers must sell their wheat in competition with the ill-paid Calmucks of the Don, and labor for the pittance paid to the barbaric serfs of Turkey, or not sell at all to Europe.

THE IMPORTATION OF FOOD.

Free trade not only reduces the price of our products, but limits the markets for our agricultural products abroad. The largest amount of provisions we have ever exported

is $80,000,000 per annum; of which less than half went to the manufacturing countries of Europe. During the first ten months of the present calendar year our imports from these manufacturing countries amounted to $186,500,000 in gold. At the same ratio of imports, the amount for the year, reduced into currency, at $1.44 for gold, would be $322,272,000 against $149,328,000 of exports, entailing a loss which must be paid for in gold, or, worse, in bonds at five or six per cent. interest! and not only cause the country this immense loss direct, but indirectly sends into this country *five times* as much food as we ever sent to the manufacturing countries of Europe!*

In this country our free labor spends about one-third to one-half its earning in food; but the cheap labor of Europe spends two-thirds for the necessaries to sustain life. Now, nothing can be more plain than the fact that two-thirds of our imports represent *imported food*, minus the profits which swell the capital or permanent wealth of the foreign manufacturers. Free trade, therefore, diminishes the markets of our farmers to this extent,—since we import during free-trade tariffs five times as much food as we export,

* The following extract from a pamphlet by Daniel J. Morrell, Esq., Superintendent of the extensive Cambria Iron Works, Johnstown, Pennsylvania, shows the average consumption of food and manufactures by the operatives for every ton of rails produced, at present prices, when labor commands two dollars per day at the works. It requires about forty hands of all kinds, from the mines to the market, to produce one ton of rails: consequently, the cost of labor at two dollars per day is $80 per ton. English labor at the iron works commands about fifty cents per day: consequently, the cost per ton is only $20. The English laborer cannot afford the luxuries contained in the following table. Most of his hire is spent for food.

Articles consumed in the Production of a Ton of Rails, and Taxes thereon.

	Value.	Tax.
Sugar	$2.00	$ 30
Coffee	90	10
Buckets, Tubs, &c.	50	2.4
Syrup	1.50	8
Matches	6	2
Tea	1.50	25
6 lbs. Soap	1.00	7.2
Vinegar	50	2
Brooms	60	2.7
Carb. Oil, Gas, Candles, &c.	50	7
Hardware, Queensware, &c.	2.00	40
Medicines, Physicians' Fees, &c.	1.25	15
Muslins	2.50	12
Hosiery, &c.	80	10
Checks, &c.	50	2.6
Calico and Ginghams	3.75	18.8
Cloths, Cassinets, and Flannels	3.75	17
Manufactured Clothing	2.00	12
Boots and shoes	4.00	24
Beef, Pork, and other meats	10.00	3
Taxes, Stamps, &c.	1.00	15
1 gallon Whiskey	4.00	2.00
1 gallon Beer	40	3
1 lb. Tobacco, smoking	60	36
1 lb. Tobacco, chewing	1.00	40
Cigars	75	25
Sundries	2.64	15
Rent	4.00	No tax.
Half-Barrel Flour	5.00	"
Butter and Cheese	2.00	"
Lard	20	"
Vegetables, Eggs, &c.	4.00	"
	$65.20	$5.83

The foregoing table also shows the tax paid by the workman on a ton of rails, which of course is an indirect tax on the employer. The following table gives the amount of taxes, both direct and indirect, which are paid by the manufacturers on each ton of rails produced, in order to demonstrate the insufficiency of the present import duties for protection, since it is shown that the excess of taxes over duties amounts to fifty-five cents.

Table showing Total Direct and Indirect Taxes on a Ton of Rails.

	Tons.	Rate.		
Pig Iron	1 43	$2.40	$3.43	
Coal	7 72	06	47	
Rails	1 00	3.60	3.60	
				$7.50
Add 12 per cent. to make gross ton				90
				$8.40
Indirect tax paid by laborer				5.83
Indirect taxes paid by manufacturers: Tax on Incomes, Stamps, Licenses, Oil, Steel, Brass Castings, Machinery and Repairs, Bricks, Gum and Leather Belting, Freights, and the innumerable other items connected with the manufacture and sale of iron, will add at least two dollars more				2.00
				$16.23
Import Duty on ton of 2240 lbs.				15.[illegible]
Excess of Tax over Tariff				55

Cost of Foreign Iron delivered here.

Cost of a ton of rail in Wales	$[illegible]
Freight	[illegible]
Commission, &c.	1.25
Insurance	1.25
Duty on a ton of 2000 pounds	13.[illegible]
Cost in gold	$[illegible]
Premium on gold at 140 per cent.	[illegible]
Cost in currency	$[illegible]

which destroys the home market of our farmers to that extent. Such are the rewards of free trade and cheap labor. They drain our country of the precious metals; they curtail the markets for our agricultural productions; they reduce the price of every production of labor as well as the price of labor, without adding one cent to our permanent wealth, and constantly drain the resources of our country; and we might continue with a category of evils *ad libitum*.

HIGH PRICES.

The tendency of high tariffs and wars is to produce *high prices* and inflated values, which excite the fears of those who are more prudent than wise.

Those who fear a fall should never attempt to rise; and those who dread high prices should be always condemned to small profits, cheap labor and its results.

We never can enjoy "good times" except by high prices and protection to labor: the road to wealth, prosperity, and power is through the busy marts of a well-paid industry; while the road to crash, crisis, and ruin is down the rugged paths of cheap labor and low prices.

Protection necessarily brings high prices at first. Our manufactures have always been in a crippled condition, our factories idle, our experts scattered, capital diverted, prior to every protective tariff or "protective war:" consequently, it required the inducement of high prices to start the ruined furnaces and mills, open the mines afresh, and bring back the labor. But prosperity follows high prices, and the demand for the products of labor increases. Want of competition then keeps up these prices; but, as the domestic manufacturer is the great purchaser of our agricultural productions, the demand for these increases in the same ratio, and the values, though high, become equal.

Domestic competition would in a reasonable time bring all values to a fair standard. This is natural; example proves it; and that such is the result let our cotton-manufacturers, who are now able to undersell even England, testify.

Protection never brings on the crash, crisis, and ruin which the over-prudent and timid fear. These grand and frequent climacterics in our history always follow free trade. Would we have suffered the crisis of '57 if the tariff of '42 had not been repealed for free trade? Would we be in danger of repudiation now if the duties on imported goods had been increased in proportion to the direct tax?

It is not, therefore, high tariffs or high prices that we have to fear, but the sudden opening of the flood-gates of free trade, which overwhelms our domestic industry, and drags down prices and values with a quick and ruinous energy at the moment when our labor is high.

The timid capitalist, the prudent merchant, the enterprising manufacturer, and, in fact, the whole domestic industry of the nation, have more reason to fear the blunders and folly of our statesmen than the effect of high prices. Sudden changes in value from the high prices of protection to the low prices of free trade should most be dreaded by all.

CUI BONO?

But why should these ruinous changes be made, when history, example, reason, and all our best interests admonish us not to make them?

Political economy teaches us that such steps are from prosperity to adversity, and that our lawgivers must descend from the sublime to the ridiculous to accomplish the fall. It is a greater sin to be a fool than a knave, if wilful ignorance bears the blame. If we vote for pot-house politicians with more "brass" than brains, and elect the mere demagogue to Congress who is incapable of making a living in business pursuits, and

who is not practical enough to understand the laws of trade, can we expect him to display the wisdom of Solomon or the sagacity of Ulysses?

We are a self-governed people, and responsible for our actions. If we make law-makers of our fools and babblers, sending them to Washington, and keep our business-men at home, we must expect to suffer for our ignorance and want of discernment.

The emigrant who comes to this country does it with the intention of bettering his condition,—to save himself and family from the cheap labor and the dependence of Europe, and to obtain the benefits of free labor and independence in America. Yet how many of them, charmed with the name of Democracy and its policy of *free trade*, *cheap goods*, and *States' rights*, are cheated by a sham, and made dupes by their ignorance!

THE WORKING-MAN.

It seems to us the working-man of America, be he native or foreign, should have tact enough to comprehend how free trade must necessarily deprive him of all the benefits to be derived from free labor, the profits of labor, and the superior resources of this country.

The questions which the working-man should solve are these:—

Shall I vote for free competition with the cheap labor and labor-saving machinery of Europe, and necessarily bring down the standard of my wages to the starvation prices of the Old World, by allowing them to sell their goods in my markets in open competition with my own? I sell my labor to make iron; and if the products of my labor sell cheap, I must necessarily work cheap. The English manufacturer can convey his iron from England to New York as cheap as ours can be sent to the same point or to market generally. He has more capital than my employers have, and more machinery, and can get as many hands as he may want at fifty cents per day. Now, it is clear to my mind that he can undersell my employer unless I work for English prices. Free trade, therefore, is dead against my best interests. I do not want many foreign goods. Ten cents per day will buy all the foreign manufactures I need. It will be a bad trade indeed to reduce my pay from two dollars per day to the miserable pittance of fifty cents in order to save forty per cent. duty on TEN CENTS' worth of goods.

On the contrary, if I protect my labor and prevent my old taskmasters from selling in our markets, I shall not only have plenty of work to supply a growing demand and what they would otherwise sell, but I shall have good wages, because here I have part of the profits of my labor, can choose my own occupation, change it when I please, and enjoy all the advantages to be derived from the superior resources of this magnificent country.

Of what avail will all these advantages be,—these productive soils, these vast fields of coal and mountains of ore, these wonderful provisions of bountiful Nature, these blessings of Providence, if we allow the nobles, kings, emperors, and all the other drones of the Old World, who have devoured the fruits of the poor and grown fat on the sweat and tears of millions, to fill their coffers at will from our mineral and agricultural treasures, by their ability to buy from us cheap and sell to us dear, as long as they can make slaves of the working-man and compel him to labor for his miserable fare of black bread and peasant's "blouse"?

We do not wish, however, to monopolize the gifts of God, or to prevent the oppressed and poor of the world from sharing our blessings, our comfort, and our independence: but we do most seriously, manfully, resolutely determine that our brethren in the Old World shall not make our wealth the means of further increasing the power of their taskmasters and our enemies,—the enemies of all free institutions. They shall not drag us down to their pitiful level while increasing their own burdens and riveting their own chains.

We cordially invite them, however, to come to us and share our liberties and our

happiness; but they must leave their masters, their bondage, and their burdens behind: we will have none of them. Here there is room enough for the poor and oppressed of the world; but there is not space for one of its patent nobility. Here all men may aspire to the highest nobility of Nature; but none can claim their greatness from the prerogatives of blood and birth. America for all men, with equal rights, equal opportunities, and equal inducements; but even here, ignorance is the slave of intelligence.

MIDDLE-MEN.

These are the middle class in society, who generally make the most money, because they are simply factors, or agents, who transact business between the agricultural and manufacturing classes. The merchant buys from the manufacturer and sells to the farmer, or *vice versâ*.

The carrier (in ships, cars, boats, or wagons) transports the products of both. They do not, however, make their living so much by the amount they carry as the price obtained for their services. If their patrons are poor and in want of profitable employment, while the products of their labor are cheap, then the middle-men will have little to carry, little to sell, and small profits. Therefore the interests of the producer directly affect those of the merchant and carrier. If the first are poor, the last must accept the same condition.

In like manner, all those who conduce to our intelligence, health, comfort, and pleasure—the teacher, the artist, and the professional man—must depend on the ability of the producer. If labor and the products of labor are cheap, then their services must be cheap. Yet how few of all those hosts of middle-men (we speak respectfully, with our hats off), who depend for their living on labor and the fruits of labor, are willing to increase the prices of labor! They live on the profits of labor, yet are ever trying to cheapen labor. They are continually trying to kill the geese that lay their golden eggs. What fools our teachers are! How silly are these wise men! Yet the ignorance of the laborer is more to blame than their *folly*.

The "penny-wise, pound-foolish" policy of most of our railroad companies is, nevertheless, still more absurd. Their "dividends" are entirely derived from the profits of their transportations: the interest on their capital is derived from traffic, and their ability to buy, of course, depends on the price they receive and the amount they carry. But our railroad-men advocate low prices in asking the privilege of importing *food* and *cheap labor*, in the shape of rails, duty free. They demand the means of levelling labor and the products of labor in this country to the standard of Europe. They would reduce prices from one-half to two-thirds their present rates, and, consequently, diminish their own profits in the same ratio. They have already sent more money to England than would have been required to develop our own iron industry beyond competition, and have, in consequence, paid twenty per cent. more for rotten foreign rails than superior domestic iron would have cost them. But, while they thus increased the cost of railroads and their equipments, they crippled their own resources by bringing ruin on our manufacturers, from whom they obtained their employment as carriers, and the farmers consequently burned their corn as fuel, because they had no market when the miner, the manufacturer, and the mechanic had no work and no money. It is, therefore, evident that the free-trade policy advocated by too many of our great railroad companies has retarded the development of the regions they traverse to such an extent that they have been forced to mortgage their lines to Europe in the enormous sum of $500,000,000, on which they have paid in interest, perhaps, more than they made in profits. But had their roads been built with American iron, mines, furnaces, mills, factories, and farms would have sprung into existence, doubling the freight, while saving both capital and interest.

When low prices ruled, they could buy iron cheap; but, nevertheless, many of them went deeper and deeper into debt as long as they were governed by their own elected policy of free trade. But when high prices ruled, they paid their debts and made money. Yet so selfish and short-sighted are they that their policy leads them to carry ten thousand tons of iron or coal at low prices, even at a loss, rather than pay a high price for one ton of iron; and unless every railroad charter is accompanied with a proviso that the road shall be built with American iron, this class of men will be free-traders, and, of course, their own enemies.

HOW TO PAY OUR DEBTS.

We are saddled now with an enormous debt, which is the direct and indirect result of a false Political Economy, or no economy at all. It may be placed to the account of free trade, and a great portion of it is to the credit of our enemies and rivals, in whose interests alone are our free-trade tariffs enacted.

The national debt, secured by first mortgage on our property, is about	$3,000,000,000
Our corporation debts are about	3,000,000,000
Our public improvement debt, about	500,000,000
	$6,500,000,000

This is over two hundred dollars per capita on each inhabitant of the country, and more than one thousand dollars to every productive person; and these last must pay it.

The interest on this vast sum must be paid annually, and it must come from the profits of labor, or not at all. It must be worked out by the productive industry of the country, and our farmers, planters, miners, manufacturers, and mechanics are bound to do it, since all other branches of industry, with but few exceptions, live on the earnings of the productive classes, and are simply agents or middle-men. They are necessary to the farmer and the manufacturer, and enhance the value of productions by placing the wheat of Wisconsin in the manufacturing towns of New England, and the fabrics of the latter among the farms of the former. But they produce nothing: therefore our farmers and manufacturers are bound to assume the debt *and work it out.*

Can they do it?

Dr. William Elder, of the Treasury Department, Washington, has shown in the most conclusive manner that they can pay it, in twenty years, even under an annual increase of wealth less than the average increase during the ten years preceding the rebellion, when our farmers and manufacturers had but a slight protection to their labor.

We quote from a pamphlet prepared by Dr. Elder, and issued by Jay Cooke, entitled "How our National Debt Can be Paid."

"INTEREST OF THE DEBT AND ORDINARY EXPENSES FOR THE NEXT SIX YEARS.

"The following tabular statement shows the result of our inquiry as to the ability of the LOYAL States to provide for the interest of the public debt and the ordinary peace expenditure until the year 1870. (All the figures of the table express millions of dollars, except the column of dates and that of percentages.)

Year.	Wealth.	Annual Product.	Annual Interest.	Annual Revenue required.	Annual Peace Expenditures.	Per cent. of Annual Revenue to Annual Product.
1865	16,112	4,318	126	325	199	7.55 per cent.
1866	17.428	4,685	148	348	200	7.42 "
1867	18,909	5,067	165	365	200	7.23 "
1868	20,516	5,498	165	365	200	6.63 "
1869	22,260	5,965	165	365	200	6.11 "
1870	24,226	6,492	165	365	200	5.62 "

* Note.—The revenue for the calendar year 1865 is an estimate made upon data well ascertained. The peace or ordinary expenses of the year is the balance left for such use after payment of the accruing interest.

"PAYMENT OF THE DEBT IN 20 YEARS FROM 1870.

"It is assumed that by the year 1870 the insurrectionary States will be fairly under the Federal Government, and in condition to contribute their due distributive share to the revenue of the Union, and that in that year the reduction of the public debt may be commenced. The following table shows the wealth of the restored Union; its annual product; the annual interest upon the debt while in progress of extinguishment; the percentage of annual product which may be applied in payment of the debt; the percentage of annual product required for ordinary peace expenditures (the amount of which is taken at 200 millions from 1870 to 1880, and thereafter at 250 millions per annum); and the total charge per cent. of all disbursements until the debt of 2750 millions shall be reimbursed.

"RESOURCES OF THE RESTORED UNION. ANNUAL CHARGE REQUIRED FOR THE EXTINGUISHMENT OF THE DEBT IN 20 YEARS.

"The wealth of the Union in 1870 is obtained by taking that of the loyal States, according to the rate of increase for the 10 years before the rebellion, and adding thereto 25 per cent. for the wealth of the rebellious States, instead of 33⅓ per cent., which was their proportion in past times. The rate of increase for the ensuing years is calculated at 7⅛ per cent. per annum, or 100 per cent. in 10 years. (It will be recollected that the rate before the rebellion was 8½ per cent. per annum, or 126 per cent. in 10 years. The annual product is also reduced from 26.8 to 25 per cent. of the capital wealth of the year.)

Year.	Millions of Dollars.			Charge per cent. upon Annual Product of the Union.			
	Wealth.	Annual Product.	Annual Interest.	Of Annual Interest.	Of Payment of Principal.	Of Peace Expenses.	Of Total required Revenue.
1870	30,282	7,570	165	2.18	1	2.64	5.82
1871	32,452	8,113	160.1	1.97	1	2.46	5.43
1872	34,777	8,694	155.6	1.79	1	2.30	5.09
1873	37,269	9,317	150.9	1.62	1	2.14	4.76
1874	39,940	9,985	145.8	1.46	1	2.00	4.46
1875	42,803	10,701	140.3	1.31	1	1.87	4.18
1876	45,870	11,467	134.4	1.17	1	1.74	3.91
1877	49,157	12,289	128.1	1.04	1	1.62	3.66
1878	52,680	13,170	121.4	0.92	1	1.51	3.43
1879	56,455	14,114	114.1	0.81	1	1.41	3.22
1880	60,564	15,141	106.4	0.70	1	1.65	3.35
1881	64,904	16,226	98.1	0.60	1	1.54	3.14
1882	69,555	17,389	89.2	0.51	1	1.43	2.94
1883	74,539	18,635	79.7	0.43	1	1.34	2.77
1884	79,881	19,970	69.5	0.35	1	1.25	2.60
1885	85,606	21,401	58.5	0.27	1	1.17	2.44
1886	91,740	22,935	46.5	0.20	1	1.09	2.29
1887	98,314	24,578	33.9	0.12	1	1.01	2.13
1888	105,360	26,340	20.4	0.07	1	.95	2.02
1889	112,910	28,227	5.9	0.02	1	.88	1.90
		316,262					
	Excess,	16,262					

One per cent. on 300,000 millions pays $3,000,000,000, the principal of the debt.

"It must be noted, however, that the figures representing the percentage of the annual product of the nation's industry required to carry on the government, pay the accruing interest, and repay the whole principal of the debt, do not express an actual taxation upon the annual product, but upon a sum equal to such product. Much of this expenditure may be borne by export duties, if adopted, some considerable sum by the proceeds of the public lands, and a very considerable amount will be raised from miscellaneous sources which are not taxes."

These figures are satisfactory and encouraging. They are based on sound data, and are estimated below the increase of the past; while there are good reasons to hope that the increase of the future will be greater than that of years gone by. But it will depend on the protection given to American manufacturers. If we open our ports to the trade of Europe, and admit the products of the cheap labor of the Old World, the doctor's figures will be sadly in error. If we continue to import over double the amount of our exports, as we are now doing, and pay the balance in gold or bonds, we will follow the example of Jeff. Davis, and repudiate our debt in less than twenty years, as the only way of paying it.

OUR FOREIGN DEBTS.

Our whole debt is now about $6,500,000,000; but of this amount we only owe about $1,000,000,000 to "the Jews," on which we must pay about $60,000,000 interest in gold. This is an annual drain on our resources. It goes out and does not return. For the larger amount of $5,500,000,000 we *owe to ourselves*, and are not one cent the poorer that we owe it; the interest is no drain on our resources, since it is simply paid from me to you, and passes from pocket to pocket. But suppose we owed the entire amount to other nations; the interest, at six per cent., would be $390,000,000. This, however, is not possible. We could not owe this amount abroad, because foreign nations would not lend it. Fortunately, they refused to lend us a dollar when we wanted it most and were least in debt. Now, however, they are lending us all we are willing to take. But on what terms? They give us less than two dollars in gold for three dollars in first mortgage bonds on our property, on which we expect to pay full interest and return three dollars in gold at the end of the term of contract. Much of the money we have borrowed from European capitalists cost us more than two for one, and we are safe in stating that for the $500,000,000 in Government bonds which they hold, we have received less than $250,000,000, and most of it in goods which our own manufacturers could have produced, and which were imported only to their injury and at their expense. If this debt is paid in twenty years, with an annual interest of only five per cent., it will drain us of $1,000,000,000 in gold. But it must be remembered that this is only half our foreign debt, and that five per cent. is less than the average rate of interest. Therefore the drain on our precious metals will be over $100,000,000 annually, if our debts are to be paid in twenty years. The gold of California and our Western mines will not afford us the treasure, at the present rate of production; and since free trade only helps to drain our gold, we are still in danger of repudiation, unless we are protected from further spoliation by the cheap labor and labor-saving machinery of Europe.

What have we to show, what will we have to show, for all this, when the time comes for payment,—perhaps in less than twenty years? The "cheap rails" we bought from England cost us, including interest, more than double the price of domestic rails, while they do not render half the service. They were imported at the expense of our own industry, to the ruin of some of our most worthy and enterprising citizens, and added to our debt, while crippling our resources. The greater part of our imports of foreign goods were, like iron, at the expense of our own manufactures. While we gave work to foreign

lls and factories, we suffered our own to remain idle, or forced them to suspend at a ;at loss; and most of our foreign debt has been contracted in this self-sacrificing .nner. We have, therefore, no value in return for our vast expenditure of treasure. is worse than a dead loss; it entails a constant loss to the nation in a yearly drain of),000,000 in gold. Had the money been expended at home, this large foreign debt uld now have been productive capital, returning ten per cent. dividends, instead of ling for six per cent. interest.

This is the result of free trade, or the want of protection to our own manufacturers. ee trade may be a benefit to England, because her cheap labor and vast acquisition labor-saving machinery—which increases the productive ability of every operative yond the capacity of one hundred negro slaves, or the unassisted labor of one hundred 'ong men—enable her to compete with the world, and make money by every exange.

When we have arrived at the same stage of development, and our resources are ilized with the same degree of economy, we can compete with England, and make oney by the trade; because our resources are superior; we produce the raw *materials* ıd the *food*, while England imports a large amount of both; and we can do this ithout descending to her standard of cheap labor. We hope the day may be distant hen our miners, manufacturers, and mechanics will be forced to work for fifty cents ɜr day.

It is, therefore, evident that the only way to pay our debts is to stop running deeper ıto debt, and give our people an opportunity to *work out* that already contracted.

They cannot do it unless they have remunerative work; and this they cannot obtain s long as we persist in going to Europe for the goods which they are anxious to furnish. 'e cannot pay this debt if we close our own mills and factories and send their experts › the prairies of the West to raise grain, while the markets for the products of the oil are cut off by the suspension of our manufactures. By closing our mills, blowing ut our furnaces, and stopping our mines, we stop the entire productive industry of the ountry. When the manufacturers cannot buy, the farmer has no market; therefore ur productive power ceases, and our debts increase.

We are forced to this, if we do not protect the labor of our people from the low prices f Europe. The free laborers of America will not toil for the miserable recompense of ifty cents per day,—we hope never; and if they would, how much of our debt could they pay, after providing for their families? They can make a better living by tilling the soil until it is exhausted, though no better use of their surplus corn may be found than to burn it as fuel.

The political economy of the United States is, therefore, plain. We must have a protective tariff, or a war with the manufacturing Powers of Europe. The first is the most desirable and the most profitable; but the last is far better than free trade.

OUR DOMESTIC DEBTS.

If our foreign debt is a burden, our domestic debt is the reverse, and the $2,500,000,000 of the national loan which still remains in the country adds to our productive wealth, while the $500,000,000 which has been exported is a heavy drain. The smaller amount is a real debt, which taxes the resources of the nation; while the larger amount is not a *bonâ fide* debt, but a simple conversion of the value of real estate into funds; and we thus make our wealth in property available as business capital. This is frequently done by all business-men in a private way; but individuals could not make their notes current, except at home, even though their wealth in lands and houses, mines, furnaces, mills, &c., were ten times greater than their "promises to pay." But the Government has power to bind the wealth of the nation for the payment of its *promises*, and thus

creates from the dead or idle wealth of the people an active cash capital, which is equal to gold in all parts of our country, and eagerly sought for in Europe. As long as we hold and use this capital, it really increases our wealth to the amount issued, if within a reasonable percentage of the aggregate value of our property and in the confidence of the people. It is now one-sixth of the national wealth, and less than the value of our annual productions.

That which we send abroad, however, becomes a burdensome debt, unless we receive gold at par for our bonds and invest it in some productive business which will pay a profit over and above its annual interest. At the rate at which our bonds are now going abroad in exchange for goods, while our manufacturers are comparatively idle, we will soon find the greater portion of it a direct present debt, entailing an annual future loss. Therefore our national loan may be made a national debt or a national cash capital, according to the intelligence of our people and the wisdom of our statesmen.

Jay Cooke has issued a second pamphlet, showing how our "national debt may be made a national blessing." From this we shall quote largely.

Many doubt that *debts are blessings*, and we do not wish to present the subject under an unfavorable light. As presented in the forcible language of Samuel Wilkinson, Esq., the arguments are in opposition to the prejudices and life-long training of "prudent business-men," who cannot divest themselves from their habits of thought. But when we consider the *Government debt* as a *Commonwealth credit*, which it would have been if created without war, we remove the "beam from their eye."

As a résumé of many of the arguments and facts set forth in the present chapter, our quotations are appropriate and to the point. We do not, however, present in full the arguments of the pamphlet. We leave their demonstration to time, but use those only which are self-evident.

HOW OUR NATIONAL LOAN MAY BE MADE A CASH CAPITAL INSTEAD OF A DEBT.

"The following is a table of the permanent indebtedness of Great Britain, France, Russia, Austria, and the United States, of the burden of the interest of the debt of each Government, of the burden of the debts per capita on the population of each, and of the ratio of the interest to the annual production of the five countries respectively:—

	Debt.	Interest.	Debt per Capita.	Rate of Int to Annual Production.
France, 1863	$2,304,000,000	$132,360,000	$62.12	
Austria, 1864	1,263,400,000	75,100,000	36.00	
Russia, 1864	1,116,800,000	27,100,000	19.64	
Great Britain, 1863	4,000,918,944	137,564,548	129.33	3.81
United States	3,000,000,000	165,000,000	86.72	3.63

"Our ability to pay our war debt has been demonstrated by an exhibit of the resources of the nation. The best statists connected with the financial department of the Government have shown that the customs revenues of the United States, the excise and internal taxes, our mineral regions scarcely yet opened, our two millions of acres of petroleum wealth, our unsold public lands, and the certain growth of the country in population and the equally certain increase of its manufactures, will be sufficient to discharge this debt to the last dollar within twenty-five years. And the debt will be discharged, if the people so ordain. Its payment, or its retention unpaid, is

a matter for the people to decide. It is their debt to discharge, if it be a burden. It is their debt to perpetuate, if it be a good.

"In studying these permanent debts, and discussing the policy of maintaining them, or discharging them by payment, the mind should free itself from the tyranny of words. Great Britain is in debt to Great Britain. Great Britain does, indeed, owe Great Britain four thousand millions of dollars. The burden of the debt crushes the mind in contemplation of it. But its vastness is not the measure of the obligation; for there is no engagement on the part of the debtor kingdom to pay the principal of the debt, and little if any expectation, and less desire, on the part of its creditor subjects that it shall be paid. The principal of the debt, being thus removed from our educated idea of a legal burden, and of the necessity to discharge a pecuniary obligation, ceases to represent the burden.

"The interest of the debt only becomes the measure of its burden. Great Britain does owe to Great Britain, confessedly, $4,000,000,000. But practically, and by consent and harmonious arrangement, Great Britain owes to Great Britain only $127,000,000 a year. And that is a very small debt for the proprietors and workmen of the 'workshop of the world' to owe to each other. Its distributive burden is but $129.33 a head, which is not assessed on pay-day per capita, but is justly apportioned, the larger share upon the proprietors of the workshop, and the smaller and smallest upon the artisans and laborers. This, practically and financially, is a fair statement of the nature and burden of the much-talked-of British debt.

"Such, too, should be the regard of our debt. The United States will owe, mostly to the people of the United States, $165,000,000 a year. The burden, nominally $86.72 upon every citizen, and less than that of the British debt, unlike that of Great Britain, will every year rapidly diminish by the rapid increase of our population by immigration and natural growth, and by the rapid augmentation of our wealth. For among the other blessings of our war will probably be the transfer of the workshop of the world from England to America.

"The Englishman who has £20,000 in three per cent. consols at his bankers, and only ten guineas in his pocket, and who gives assent to a proposal made to him to go mine for coal on Vancouver's Island, has got £20,000 in cash to go into the operation. He knows that positively. The world knows it. British consols are cash capital. This cannot be controverted. And the $4,000,000,000 of British debt is national cash capital to the industry and commerce of Great Britain. For half a century this seemingly and nominally huge and burdensome debt has served to vitalize the manufacturing and trading genius of the English people, and, as money, has enabled the British to do for that long time the marine carrying for the world, and to make for the world cloth, iron, steel, tin, and hardware. This enormous mass of capital, infused into the business of England at the close of her twenty-two years' war with the French Republic and Empire, almost always of par with gold, convertible daily and hourly into gold, accepted as gold in all transactions, was the source of that prodigious development of mechanical industry and accumulation of wealth which so suddenly bore upward the English after the battle of Waterloo to the command of the trade and finances of the globe."

But England does not import over double her exports. She does not buy twice as much as she sells, and pay the difference in bonds at from five to six per cent. interest. Nor does she owe $1,000,000,000 to other nations. Not one cent of her bonds goes out of the hands of her citizens, if she can prevent it by legislation; and this has been so effectually done that she is a lender of money, instead of a borrower.

Her intelligence enabled her to make her national loan a national blessing instead of a debt, and the industry, thrift, and enterprise of her people have made her

$4,000,000,000 in bonds a productive cash capital whose accumulations have increased the principal more than ten times since its creation.

"The Englishman's £20,000 in consols are mortgages, each and all, upon every nobleman's estate and every spinning jenny in Great Britain; upon every coal-mine and every ship; a mortgage of record upon every mug of beer held in the fist of a working-man throughout the kingdom; a mortgage, signed, sealed, acknowledged, and delivered, on the whole life, ay, on the death and burial, of the people of all England. It is the nationality of this promise to pay, backed up by the most vigilant, distrustful, and thorough system of taxation, for the enforcement of which the whole power of the Government, military and civil, is pledged, that makes British consols the equivalent, practically, of British guineas; that makes the four thousand million dollars of British debt an addition of four thousand million dollars of money to the capital the kingdom otherwise possessed at the beginning of this century.

"It is precisely so with the war debt of the United States. Seven-thirties are available for any enterprise to which unoccupied lands, undeveloped mines, unestablished arts, and unseized commerce, invite Americans. They are cash capital, literally, absolutely, and without figure of speech. Practically they are cash in bank and cash in the pocket. The artificial measures of their value which stock exchanges have succeeded in instituting, at times, nominally gave fluctuation to their worth as they lie in the bureau-drawers of farmers. But in reality the depreciation of Wall Street does not whittle off the thousandth part of a hair's-breadth from that worth. Those farmers know that they are a first bond and mortgage upon all the United States and on all the people of the United States. But whether three per cent. above par or one per cent. above par, holders of this war debt of $3,000,000,000 can any day and any hour, from San Francisco to New York, and from Portland to New Orleans, convert it into cash.

"Our national debt should be held firmly in place, as the foundation of a system of diversified national industry, which shall relieve us from dependence upon Europe, shall give us the near and cheap home market instead of the distant and costly foreign market, shall double the profits of farming by doubling the markets for farm-products, shall swell the class that is devoted to agriculture,—which is the sheet-anchor of democracies,—shall free man by freeing labor, by giving it many markets in which to sell itself to competing bidders.

"A permanent revenue tariff will be necessary to enable us to pay the interest of the debt and meet the current expenses of the Government. This tariff upon foreign manufactures, necessary in itself, is also necessary to sustain the internal taxation and excise system of the country. It is a wall to prevent our domestic manufactures from being washed away by importations. We can have no trustworthy and increasing internal revenue without we have permanent protection.

"The bonds of the United States, accepted throughout the United States as the highest security, and having a uniform value in every one of the States, are the only real and safe equivalent for gold and silver, and the only available basis for a uniform bank-note currency that shall be money all over the Republic. Commerce demands this uniform currency. Politics require it. The money that is at once current in Massachusetts and Alabama, that has par value in Nebraska and South Carolina, in Virginia and New York, that is taken and passed without scrutiny or suspicion by the advocates of slave labor and the advocates of free labor, by extremists in the South and extremists in the North, by the people of the two sea-boards and the people of the Mississippi Valley, has the mission to wear down the sectional barriers which the doctrine of State rights and the partisanship of politics have, for three-quarters of a century, been building up into fortified camps of division and civil war. And the uniform national banking currency will perform this mission.

"There is not now any other basis for this currency, nor can any other be devised,

than the debt of the whole United States. The issue of national bank notes at present is restricted to $300,000,000, and the States in rebellion are not reconstructed, and the national banking system has hardly crossed the Mississippi River. No man will say that that volume of currency is enough for the coming wants of the nation, who considers the demand for money to spring up in the resurrected and reinvigorated South, and soon in the West and the far Northwest; who considers the prodigious immigration that began to pour into the country before the rebellion grounded arms, and which will for years flood to us from Germany, England, France, Ireland, Norway, and Sweden; who considers the vast attraction of manufactures and arts from Europe to America by a tariff system that promises lasting rewards to labor in the midst of politics, that crown labor with freedom and social equality; who considers the marvellous development of industry—mining, manufacturing, and agricultural—of which our country is destined soon to be the theatre, and every hour of every day of which will demand currency as the machine of its exchanges.

"This is not a hazardous opinion which declares that in less than twenty years our national bank note circulation will be one thousand millions of dollars. Bear in mind that there are now in the United States thirty-five millions of people, and that for the last half-century the population of our country has doubled in numbers in every twenty-three and a half years. The currency that sixty-one millions of people, unequalled in industry and untrammelled in enterprise, will require, has got to have the basis of a national credit. There is no other foundation for it to stand on that will impart to it at once security and nationality.

"*Secondly.* There is no reason to apprehend that the interest of the national debt will be burdensome to the people and oppressive to the development of the resources of the country; because, after legislation has readjusted the internal taxes and excise, and re-remodelled the tariff so as throw the weight of the debt on luxuries and accumulated wealth, where it ought to be thrown, and made to rest lightly on the necessaries of life and on daily labor, it can almost wholly lighten the burden by diffusing it, year after year, over a larger population, through greater production, increased wealth, and increasing incomes. Time will effect this, unaided; but legislation and associate action can rapidly hurry this diminution of the debt and of the weight of the interest. Organize immigration, remove to the United States the cotton manufacture of England, bring here a large part of the silk and muslin manufacture of France, the iron make and the cutlery manufacture of Britain, lift up and bring here a large portion of the mining population of Europe, set it down in Pennsylvania, Virginia, and that further imperial mineral domain which extends through seventeen degrees of longitude and sixteen degrees of latitude, and contains an area of more than a million square miles, literally crammed with gold, silver, copper, iron, coal, lead, tin, salt, quicksilver, gypsum, asphaltum, and marble, and which asks only an amount of labor relatively equal to that expended on California, to yield four hundred millions per annum out of two minerals alone,—gold and silver. In aid of this organized immigration, readjust the import duties, so as to make it more profitable for the Lyons weavers and the Spitalfields and Manchester spinners to take up their looms and weave in America, than to manufacture where they are and squeeze through our custom-houses. Diffuse the burden of the interest of our debt, abroad as well as at home, by imposing export duties upon products that Europe has got to buy of us in spite of herself,—on our cotton, tobacco, petroleum, and breadstuffs. There will be international justice as well as political economy in summoning the nations which armed, clothed, and fed the rebellion, lent it money, and built, manned, supplied, and refitted the corsairs which swept the commerce of the United States for four years from all seas, to help to pay the debt which they helped to create. This summons, through the imposition of export duties, they will have to obey. They can't help themselves. They must have our four great staples, and pay our price for them. We say

'export duties,' knowing that the Constitution of the United States forbids them. We use the words only to convey an idea, and because of their popular significance. Excise duties of sufficient amount should be levied on these staples where produced. They would carry with them these taxes if they went abroad.

"If they were consumed at home, the laws would see to it that, by suitable drawbacks or lighter taxation on the manufactured article, the domestic interests of the country were sufficiently protected. The rebels, in copying our Constitution, omitted the clause forbidding export duties, intending to make England and France pay the cost of their war, and the expense of establishing and maintaining their Confederacy, out of taxes upon the cotton and tobacco they would have to buy."

In regard to the payment of the national debt, it is pretty certain that the Government could not pay it now, or one-tenth of it, even if they had the money to do it; and it may require something more than an offer when the bonds mature. Nothing less than the suspension of interest will induce the people to give up their bonds. They are better than gold to the laboring-man or the banker, because they constantly accumulate. But, nevertheless, we do not advocate any scheme, however attractive, which tends to repudiation or the non-payment of the principal of our national loan. We think it highly important that we should know ourselves able and willing to pay our bonds as they fall due, and that the world should see and feel our power not only to make war successfully, but to pay the costs of war. If we provide for the payment of both interest and principal of our present debt, we shall be able to raise double the amount in another emergency. But the simple fact of our will and ability to pay our debts will prevent their accumulation in future.

GOLD *vs.* NATIONAL CURRENCY.

Gold or silver is necessary to settle the balance of our exchanges with foreign nations, just as bank-notes are necessary to business-men. The value of gold is unchangeable and the same in all civilized countries. It flows to all manufacturing countries that export or sell more than they import or buy; but it flows from all agricultural countries that import or buy more than they export or sell. It represents the profit of trade or commerce, and the people who import gold grow rich, while they who export it grow poor, independent of the increase of national wealth in property.

The mere accumulation of gold, however, without investing it in labor-saving machinery, furnaces, mills, and productive property generally, would be of no more use to us than the gold of Mexico and Peru was to Spain.

For domestic purposes and home circulation our present national currency is more available than gold, and, being secured by first-mortgage bonds on our property, while the issues are regulated by the Government, there is no danger from suspension and bankruptcy.

Government bonds in the vault of the banker are worth more to him than gold, because they return him five or six per cent. interest and are still security for his banking capital or issue, which returns as much profit as if they were secured by deposits of gold.

Business-men who deal with the banks will eventually reap benefit from this, because capitalists will be able to lend their money at lower rates and extend their accommodations. The people will also profit from the increase in the amount of capital, because it tends to make money more plentiful, and when money has a real instead of an inflated or fictitious value it can scarcely be too plentiful. When our bonds are at par, our currency will be equal to gold, and far more convenient.

Gold does not represent wealth more than real estate and certain kinds of property, since productive farms, mines, furnaces, mills, and factories, and labor-saving machinery generally, are more valuable than gold, under a wise political economy.

The issue and redemption of circulating notes, which answer a better purpose for domestic business transactions than specie, can be secured as effectually on a property as on a gold basis, provided the faith of the Government is pledged to assess fairly the wealth of the nation to support it and secure its general circulation and its final redemption, if so desired.

Private issues of notes on either a gold or property basis have less utility, and constantly decrease in value as they recede from the point of issue, are affected by panics, fluctuations in values, and individual bankruptcy. But a national currency, secured as ours is, provides a better circulating medium than gold, or the issue of notes by private banks on the deposits of gold in their vaults.

The creation of bank-notes, therefore, from the real estate or fixed wealth of the people, as a circulating medium, or money, increases the value of the real estate on which it is based, by giving the means to develop its resources, thereby changing unproductive to productive property,—the seam of coal and bed of ore into iron, and iron into railroads and labor-saving machinery. These become more valuable than gold in ratio to cost, because, while intrinsically valuable, they enable us to increase our productiveness a hundredfold. The bank-note thus becomes the machinery by which we develop our resources, and is the first step towards the accumulation of gold, instead of a result of its possession.*

The check and the bank-note stimulate circulation, giving increased value to labor and the products of labor; and wherever these notes, properly secured, are most in use, there the inward current of gold is most firmly established.

"That such is the case is proved by the fact that for a century past the precious metals have tended most to Britain, where such notes were most in use. Their use increases rapidly in France with constant increase in the inward flow of gold. So too does it in Germany, towards which the auriferous current now sets so steadily that notes which are the representatives of money are rapidly taking the place of those irredeemable pieces of paper by which the use of coin has so long been superseded.

"Whence flows all this gold? From the countries in which employments are not diversified; from those in which there is little power of association and combination; from those in which, therefore, credit has no existence; from those, finally, which do not use that machinery which so much increases the utility of the precious metals, and which we are accustomed to designate by the term *bank-note*. The precious metals go *from* California, *from* Mexico, *from* Peru, *from* Brazil, *from* Turkey, and *from* Portugal, the lands in which property in money is transferred only by means of actual

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* This may seem strange doctrine to those who advocate a "hard money" currency; but if we can state the matter properly, it must be as convincing as it is correct.

Gold is always the most difficult property to acquire, while it is the most useless for the purposes of development, unless invested in some other property which is productive. Therefore, productive property is worth more than gold at ordinary or common values; but property cannot be made productive unless money is first obtained to develop it. Our coal-fields and mountains of iron are worth more than all the coined gold of the world; but we cannot convert them into gold until we have the means of converting them first into steam and iron. How, then, can we acquire the means? By the ruinous process of exhausting the soils to feed the poor of Europe! This, we have shown, is a losing business. But if we accumulate a little gold during protective periods it is considered proper to hide it away in the vaults of a bank, and issue bank-notes, as a more convenient medium of exchange and circulation. Would it not be more practical and business-like to deposit our coal-fields, our mountains of ore and fountains of oil, which are more valuable than gold, with the common treasury of the nation, as security for the means to increase their value? A piece of paper, stamped by a powerful Government and secured by mortgage on lands and mines which are invaluable, is as acceptable and available at home as gold. The faith of the nation is pledged, every one of us is interested, and the paper becomes money,—$3,000,000,000,—without making us one cent the poorer, while it gives us the means of enriching ourselves by a full development of our resources. Could not this have been done without war? Is there no way of providing money as the means of development without compulsion? If so, is it safe? Will it bind the people to the Government and at the same time secure the people? At present, what one pays in *taxes* another receives in *interest*; while the capital is constantly in use, realizing from ten to twenty per cent. increase to the wealth of the nation. "Protection" is the only alternative.

delivery of the coin itself, *to* those in which it is transferred by means of a check or note. It goes *from* the plains of Kansas, where notes are not in use, *to* New York and New England, where they are, *from* Siberia *to* St. Petersburg, *from* the banks of African rivers *to* London and Liverpool, and *from* the 'diggings' of Australia *to* the towns and cities of Germany, where wool is dear and cloth is cheap.

"All the facts exhibited throughout the world tend to prove that every commodity seeks that place at which it has the highest utility; and all those connected with the movement of the precious metals prove that they constitute no exception to the rule. Bank-notes increase the utility of those metals, and should, therefore, attract, and not repel, them. Nevertheless, the two nations of the world which claim best to understand the principles of commerce are now engaged in a crusade against those notes, in the vain hope of thereby rendering their several countries more attractive of the produce of the mines of Peru and Mexico, Australia and California. In this case England follows in our lead,—Sir Robert Peel's restrictions being later in date, by several years, than the declaration of war against circulating notes fulminated by our Government.

"It is a pure absurdity, and its adoption here is due to the fact that our system of policy tends to that expulsion of the precious metals which always *must* result from the long-continued export of the raw products of the earth. The administration that adopted what is called free trade was the same that commenced the system of *compelling* the community to use gold instead of notes; and the result was found in the disappearance from circulation of coin of any description whatsoever. From that time to the present, the motto of the generally dominant party of the Union has been, 'War to the death against bank-notes;' and, with a view to promote their expulsion, laws have been passed in various States forbidding their use except when of too large size to enter freely into the transactions of the community. As must, however, inevitably be the case, the tendency to the loss of the precious metals has always been in the direct ratio of the diminution in their utility thus produced. At one time only in almost twenty years has there been an excess import of those metals; and that was under the tariff of 1842. Then money became abundant and cheap, because the policy of the country looked to the promotion of association and the extension of commerce. Now it is scarce and dear, because that policy limits the power of association and establishes the supremacy of trade."*

HOW TO SECURE THE PRACTICAL AND PERMANENT DEVELOPMENT OF OUR RESOURCES.

As an appropriate conclusion to this chapter, we present a scheme, from the pen of Mr. Bannan, to secure the results pointed out as necessary to the practical development of our resources.

It is as necessary that we should have certainty and permanence in our financial affairs and commercial relations as it is that we should have protection to our domestic industry. The plans presented are simple, practical, and sure to accomplish their object. Should these propositions be accepted by Congress and established as permanent laws, our national debt will indeed prove a blessing, and the development of our magnificent resources will become the wonder of the world, and America the seat of liberty, learning, and wealth.

* Henry C. Carey's Lecture on Money.

"NATIONAL CURRENCY.—FOREIGN COMMERCE.

"A FEW SUGGESTIONS RESPECTFULLY SUBMITTED TO CONGRESS AND THE PEOPLE.

"In December, 1857, the subscriber submitted a plan to Congress for the creation of national currency, similar to the one now established. In that recommendation is embraced a plan for regulating the issue of a national currency, so as to provide for the future wants of the country, while at the same time it would effectually check an over-issue without any future legislation on the subject. During the progress of the rebellion there was a natural repugnance to limiting any thing, because the wants of the country were unknown; but the rebellion is now over, and this question is necessarily forced upon the consideration of the people.

"All business-men are aware of the great importance of stability, particularly in currency and tariffs, and, in order to have this stability, these questions must be removed from legislation as far as possible. Our plan obviates the difficulty effectually. We all know that an inflated currency runs up prices far beyond their real value; while a contracted currency depreciates all kinds of values. With State banks, and even with a national bank, over-issues could only be partially controlled, and the country was always visited with periodical expansions and contractions, carrying ruin everywhere. Under the old system, this could not be avoided; and even under the national-bank system similar effects will be sure to follow if left open for Congress to legislate upon whenever there is a clamor made for more currency by speculators and money-changers.

"Our plan is this. First ascertain the relative value of property compared with money, so that the proportionate value of each is maintained. This can be done by taking a period of prosperity, when there was no over-trading, and ascertain the returned value of the property of the country and the amount of currency required at that period to transact the business. Our impression is that it will be found that for every $30 of the returned value of real and personal property there ought to be an issue of $1 in currency: this, we believe, would give all the currency required. We made an estimate in 1857, and we found that $1 in currency to $30 of the returned value of property (excluding slave property, which, fortunately for the country, has ceased to exist) would have given at that period a volume of currency equal to about $400,000,000,—all that was required at that time. We have no full and complete data at hand now, but, from the best information we could glean, the present value of real and personal property would be in the neighborhood of $18,800,000,000. The issue of $1 for $30 would give a volume of currency equal to $628,000,000 in round numbers. This, we believe, would be ample for a time of peace. The relative proportions might be raised or lowered according to the supposed wants, if $1 to $30 is considered too high or too low; but it is important that it should be fixed permanently by Congress as early as possible, as after this year none but a national currency will be in existence.

"The value of the property in every State is ascertained every three years. The average annual increase for the three past years is known, and the Comptroller of the Currency should be prohibited from issuing charters for national banks to issue currency beyond this point annually. All applications for charters can be registered for each State, and these charters granted in rotation so soon as the increased property will warrant it. This plan requires no further legislation; it provides for the increased wants of the country as the business and property increase, and effectually checks over-issues, over-trading, and wild speculation; and, besides, it gives each State its proportion of currency according to its wealth and business, which is the most equitable mode of distribution,—much better than any distribution that can be fixed upon by uncertain legislation by Congress.

"The plan is simple, comprehensive, easily understood, and must commend itself to every thinking business-man of the country.

"The State bank currency will all be withdrawn early in the ensuing year. Congress will, in all probability, provide for the gradual funding of the legal tenders bearing interest issued by Government, if not the non-interest-bearing legal tenders, and the limit could now be fixed so that, when all the other paper issues are withdrawn, the national bank issues will gradually take their place up to the limit.

"After a resumption of specie payments by the banks, the people will, no doubt, desire a withdrawal of all notes of a less denomination than five dollars, and gold and silver will, of course, replace it, which would give us all the metallic currency required.

"With such a limit to the issue, while it provides for all our future wants and all sections of the country in proportion to its business and wealth, it would inspire great confidence among the business community and all other classes, and would prove to be the best and most stable currency in the world.

"FOREIGN COMMERCE.

"Closely connected with the currency is our foreign commerce. Whenever there are over-issues there are over-importations. A well-regulated currency would regulate the foreign commerce to a considerable extent, but not altogether. In the two great commercial countries of England and France the importations and exportations are regulated by the national banks, which raise the rate of interest when importations are excessive, and lower it as they decrease. Here we have no such national regulator to regulate interest and importations. In 1850, Stephen Colwell, Esq., of Philadelphia, an extensive iron manufacturer, and who, perhaps, is better acquainted with the protective policy in all its details than any person now living, suggested the idea of a sliding scale, which we think is the most judicious recommendation yet made on this subject. It is to fix a fair rate of duties sufficiently protective while they are not prohibitory, and then to authorize the Secretary of the Treasury, whenever the exportations do not exceed the importations, say 10 or 15 per cent. (exclusive of coin), to increase the rates of duties, say 15 per cent., until the exportations exceed the importations, say 10 or 15 per cent. This would take all legislation on the subject out of Congress, and would prove to be an effectual check against excessive importations, and thus keep our proportion of coin in the country.

"In carrying out this idea we would suggest the following section to be added to the newly-adjusted Tariff Bill that will be brought before the next Congress:—

"'*Be it enacted, &c.* That, leaving out of view both the export and import of gold and silver, whenever the exports do not exceed the imports in value fifteen per cent. during any fiscal quarter of any fiscal year, the Secretary of the Treasury is hereby authorized and required to raise the duty on the value of all articles of foreign import (excepting such articles as have been exempted from the provisions of the act) 10 per centum within thirty days after the expiration of each and every fiscal quarter during which the exports, as aforesaid, do not exceed the imports, as aforesaid, fifteen per cent.'

"The same power ought to be given to reduce the duties also, when our exportations are excessive, which would draw from other countries more than our due proportion of coin, and thus destroy the markets abroad for our products. If, in after-years, under the stimulus of this truly protective system, our manufacturers should obtain such a foothold as to require less protection, Congress could make a certain percentage of reduction on the whole scale of duties to meet the new state of progress in our manufactures and commerce with other countries.

"This section would also remove the tariff question from further legislation, and would give great confidence and security for the investment of capital in all branches of manufactures.

"The knowledge that such a power is lodged with the Secretary of the Treasury would tend to check importations, because importers would watch the monthly and

weekly reports of our foreign commerce, and govern themselves accordingly. In either case, this power, guarded by law, could be better exercised by the Secretary of the Treasury, who has all the figures in his possession, than to trust to the uncertain legislation of Congress on this subject. And, besides, great fluctuations might occur at a time when Congress was not in session.

"With these questions settled, the drain of coin could be checked, gold would rapidly decline in value, and we would then gradually descend from the high war to peace prices; and when expedient, a resumption of specie payments could be effected without disturbing the business of the country under the national currency system. As all the property of the country is pledged as a basis for our national currency, and, of course, a dollar in paper, with gold at par, would be just as good as a gold dollar when resumption is effected, consequently, there would be no run on national banks for coin, as there would be if State institutions were still in existence, whose issues are based only on credit, which is liable to sudden fluctuations.

"With our currency and foreign commerce thus regulated on a permanent and equitable basis, providing for the future wants of the country without any further disturbing legislation on these important questions, our country would enter on a career of gradual increasing prosperity and wealth, unparalleled in the history of nations, without any of the great drawbacks which have so frequently checked our onward career heretofore.

"We consider it the duty of every citizen to aid, as far as it is in his power, in establishing good laws and a good government in the ordeal which our country is now passing through since the great rebellion is crushed, and we respectfully submit these suggestions to Congress and an intelligent people for their consideration.

"Since the above was written, we have procured some valuable statistics, which we append. These statistics show that an issue of $1 in currency for $30 of the value of real and personal property would give us an abundance of currency for all the wants of the country in a time of peace.

In 1860, we had 1562 banks, with a capital of $421,800,000, in round numbers, with a circulation of	$207,102,000
Coin, say	50,000,000
Total currency	$257,102,000

"At this period it is well known that all kinds of business were prostrated, but few improvements were progressing, and the currency of the country, for business purposes, was largely diminished.

"The returned value of all real and personal property in 1860 was as follows: we give the statistics in full, as they contain interesting information:*—

Total value, including slaves		$16,159,616,068
Value of slaves, at $500 each		1,976,300,500
Total value, excluding slaves		$14,183,215,568
Value of Free States		$9,325,945,381
Loyal Slave States	$1,631,504,580	
Less slaves	241,340,000	1,390,164,580
		$10,716,109,961
Value of Rebel States		$5,202,166,107
Less value of slaves		1,735,060,500
		$3,467,105,607

* We are indebted to the kindness of Dr. Elder, of the Treasury Department, for these statistics.

Total value of the Slave States	$6,833,670,687
Less value of slaves	1,976,400,500
Total	$4,857,270,187

"Our limit of $1 in currency for $30 of property would, in 1860, have given, on a valuation of $14,183,215,000, $472,773,000 in currency, which would have been ample for the country in a state of high prosperity at that period.

"After the commencement of the rebellion we have no complete statistics of circulation; but it is estimated that the State bank circulation in the loyal States, January 1. 1863, was about $195,000,000, independent of the national circulation.

"The following shows the whole issue up to October 31, 1865, by the National Government, National banks, and the estimated circulation of the State banks:—

"GOVERNMENT ISSUES.

	Bearing Interest.	Total.
1 and 2 years 5 per cent. notes	$32,954,230 00	$32,954,130 00
United States notes, old issue		392,070 00
" " new issue		427,768,499 00
Compound Interest notes, March 3, 1863	15,000,000 00	15,000,000 00
Compound Interest notes, June 30, 1864	202,012,141 00	202,012,141 00
Postal Currency		9,034,151 64
Fractional Currency		17,456,603 06
	$249,966,371 00	$704,617,694 70
Of this $249,966,371, interest-bearing, $50,000,000 has since been funded, and the balance, except probably $10,000,000, is hoarded, and not in circulation as currency: therefore we deduct from the total issue		239,966,371 00
Which leaves in circulation		$464,651,323 70
National bank issues, October 31		204,000,000 00
Estimated issue of State banks, October 31		60,000,000 00
Total currency, October 31, 1865		$728,651,323 70

"The statistics show that the value of the property of the country, under only a moderate degree of prosperity, from 1850 to 1860, increased annually at the rate of about 8½ per cent., or a little more than doubled in the ten years, independent of slave property. We can safely estimate that the actual value has increased 50 per cent. within the last five years, notwithstanding the destruction by war in the Southern States, and without taking into consideration the increased values caused by an inflated currency. This would give the value of the real and personal property as follows:—

December 31, 1865, at	$18,846,188,258
$1 currency for $30 in property would give currency	628,262,752
Amount of present circulation, as above	728,651,323
Making a reduction of	$100,388,571

"A gradual reduction of this amount of currency in the year 1866, allowing for the annual increase of property, would bring us down to peace prices, and would give us an ample currency for all manufacturing and business purposes, and for the development of our country, without making money either too cheap or too dear, or disturbing the relative value of property and money.

"It will also prepare the country for a resumption of specie payments after another crop of cotton is raised, without destroying values or causing much disturbance in money matters, with the tariff adjusted according to the foregoing recommendations.

With the State bank currency removed, and all our currency *national*, based on all the property of the country, there would scarcely be an *ignoramus* found who would run a bank when his paper dollar is equal in value to a gold dollar.

"The State bank notes will be taxed out of circulation after the first of January, no more legal tenders will be issued by Government, and Congress will have to increase the volume of national bank currency to take the place gradually of the withdrawal of State and national currency. In doing so, they can fix the limit proposed for the issue of paper currency in connection with the present Government currency, on the basis *proposed*; and if Congress should hereafter provide for the gradual funding of the Government issues, the same law provides for the increase of the national bank currency up to the limit fixed. When the period for resumption arrives, and all the channels are gradually filled up with coin below one dollar, which would give an addition of coin of about $30,000,000; and eventually below $5, which would give coin to the amount of about $120,000,000, the issue of national bank currency could be suspended during this process, except so far as to equalize the amount due to each State, until the vacuum caused by the withdrawal of fractional currency and the issue below $5 is filled up.

"High prices, of course, require a larger volume of currency to transact the same amount of business than if prices were low. But lower prices would not affect the prosperity of the country, but rather increase it, by the stimulus given to industry in the increased consumption of the country; and, notwithstanding the clamor of speculators, non-producers, money-changers, and shavers in favor of an inflated currency, the great mass of the producers and consumers will demand a gradual reduction to a specie basis n our currency as rapidly as prudence will permit without deranging values to too reat an extent; and this can be accomplished better now, with small stocks on hand, han at any other period. The recent remarks of the Secretary of the Treasury on this ubject meet the approbation of the business community and the public generally.

"Currency questions are generally intricate, confound the minds of those who have ot given much thought to the subject, and are difficult to understand; but this plan, hich covers the whole ground and controls the whole question, is so simple that any gislator, of even ordinary abilities, can easily comprehend it.

"BENJAMIN BANNAN.

"POTTSVILLE, November 10, 1865."

NOTE.—Since the promulgation of the Report of the Hon. Freeman Clarke, Comptroller of the Currency Department, it appears that the *actual* paper circulation of the country was, on the 1st of October last, only $160,844,229. bably an issue of $1 in currency to the value of $40 of the assessed value of the real and personal property of country would give a sufficient volume of currency for all the wants of the country. It is only the limit ol on the value of property that we contend for, whether that issue be proportioned to $1 in currency to $30, $40, or $45 in property. It is absolutely necessary to fix a limit to inspire confidence, and we know of no r mode of limiting it so as to provide for the future wants of the country without constant legislation on this ject.

CHAPTER XXIX.

THE ELABORATION OF IRON AND STEEL.

"Nothing is New"—The Iron Age—Early Manufacturers—Ancient Iron-Master—The Catalan Forge—Improved Bloomery—Water-Blast—Patent Forges—The Blast-Furnace—Smelting Operations—The Economy of Smelting—The Hearth—Action in the Blast-Furnace—Improvements in Hot-Blast Ovens—The Puddling Process—Puddling by Machinery—The Boiling Process—Nasmyth's Invention—The Silesian Gas Furnace—The Manufacture of Steel—Conversion of Bar Iron to Steel—Steel of Cementation—Heath's Invention—Blister Steel—Shear Steel—Cast Steel—Cementing Furnace—The Pneumatic Process—Bessemer *vs.* Kelly—The Bessemer Process, as now practised in England—Machinery employed—Converters—Improvements.

Solomon said, "Nothing is new," and philosophy teaches us the same; but we have heard the saying of the wise man tortured into a different meaning,—that nothing now exists which did not formerly have the same shape and character. In a word, that steamships ploughed the ancient waters before the days of Noah, and that the scream of the locomotive woke the echoes of the antediluvian world!

The "Patent Office Reports" of the days of Methuselah would be very interesting if they existed; but, though Tubal-cain was an "instructor of every artificer in brass and iron," it is not very likely that his descendants ever attained to the perfection of modern iron-masters. If they did, the more favored posterity of Methuselah and Noah did not preserve the arts and sciences beyond the building of the Ark.

The antediluvians could not have been adepts in the manufacture of iron; for that metal is a civilizer, and we are told that the "earth was filled with violence," and that the "imaginations" of men were "evil continually." Had they been industrious manufacturers, this would not have happened: they would have been too busy to breed mischief.

"Bronze or brass formed the principal tools, weapons, and metallic manufactures of the early ages and the half-civilized nations of modern times. Whatever may have been the original significance of the ancient poetic idea of a succession of the ages of gold, silver, brass, and iron, it appears to have had a real as well as an allegorical foundation in the world's history. We appear, in the literal sense at least, to have fallen emphatically upon the iron times, when the arts of life have rendered that metal more valuable even than gold, and susceptible of becoming, in the hands of the artificer, many hundredfold more precious, weight for weight, than the finest gold.

"At the time of the discovery and first settlement of America, the natives had in a very few instances advanced beyond that primitive stage of civilization in which the use of metals was confined to trinkets of gold, silver, and copper, worn upon the person of the savage. Their most effective tools and weapons were sharpened flint-stones and shells, and they possessed no other mode of felling a tree, or scooping a canoe from its trunk, than by the application of fire. Some tribes, more advanced, possessed, in addition to these rude ornaments and implements, the art of casting images and other figures in gold and silver, many of which are still found in the *huacas* or graves of the races. Chisels, hatchets, and a few other tools and weapons of copper, alloyed with tin, so as to cut wood with facility, were also made by the Peruvians and Mexicans, who thus appear to have reached the brazen era of civilization. Although the working of other metals thus everywhere preceded that of iron and steel, the use of these in the arts was early known.

"Implements not only of copper, so tempered—by a process no longer known—as to be elastic and cut granite with ease, but also iron, have come down to us from the Egyptians. Of the different nations of antiquity, including the Greeks and Romans, who possessed in considerable perfection the art of working iron and steel, the people of Chalybia, between India and the southern shores of the Black Sea, were the most celebrated, and especially excelled in the manufacture of steel. The Greeks appropriated the name of that country to designate steel of the best quality; and our own vocabularies still retain a synonym derived from that source. The 'northern iron' mentioned by Jeremiah, and the 'bright iron' of Ezekiel, in which the Tyrians traded, were probably the products of that country,—'the mother of iron,' as Scythia was called by a Greek poet.

"The early Britons are supposed to have been first supplied with iron from the same source, and were probably also taught the art of smelting it by the Phœnicians, who so early traded in this Pontic iron, which they bartered for the tin of Britain.

"If chariots armed with scythes and spears, broadswords, iron rings, and iron money, indicate a knowledge of the art before the Roman conquest, an improvement in the method of smelting and working the metal was certainly communicated by the invaders.

"A *fabrica*, or great military forge, was erected at Bath, near the well-wooded hills of Monmouthshire and Gloucestershire, A. D. 120; and the bed of iron cinders in the forest of Dean, in the vicinity of Sheffield, and other parts of the island in which Roman coins were imbedded, gave evidence of their early activity in the iron manufacture.

"The earliest of these masses of scoriæ were found on the hill-tops, where the earliest furnaces were erected, to obtain stronger currents of air, which were admitted through holes on all sides. The rudeness of these wind-furnaces was indicated by the half-exhausted state of the slag.

"After the invention of the bellows, at first operated by the hand or foot, and in process of time by water-power, the furnaces were built in the valleys; and the slag of the ancient bloomeries long furnished a supply of material for the best iron."*

There are notices in Homer and Hesiod of the art of reducing πολύκμητος,† or malleable iron, from the ores in the furnace; but it is probable that the Greeks obtained most of their iron through the Phœnicians from the Black Sea and Laconia. It has been found in the pyramids or tombs of Egypt, and obtained by Mr. Layard from the ruins of Nineveh. Indeed, the Assyrians seem to have been well acquainted with the manufacture and use of iron, since picks, hammers, knives, swords, and saws were found among the fallen palaces of Nimroud.

The furnaces used at this early day were undoubtedly much the same in form as that represented in figure 176; but the blast was probably natural, since the bellows do not appear to have been used, judging from the imperfectly-fused scoriæ found in the waste-heaps of the ancient furnaces. The Romans used those wind-furnaces or bloomeries in England as late as 120 A.D.; and Mungo Park saw one of those rude furnaces in blast during his travels in Africa.

From these resulted the blast-bloomery or oven of India, and the more recent Catalan forge still in use.

The early modes of manufacturing iron are still preserved in barbarous or half-civilized countries; and, in fact, some of them are practised even among ourselves to-day. The Catalan forge or bloomery, as often used in the mountains of the South, is as primitive in style now as it was one thousand years ago; and the clay ovens of the *wootz* manufacturers of India, built by the natives at the present day, is probably the very same in style as those which were used by them at the time of the invasion of Alexander; while it is a uniform process from the Himalaya Mountains to Cape Comorin.

* Bishop's History of American Manufactures.

† Much-wrought.

"The furnace or bloomery in which the wootz ores are smelted is from four to five feet high; it is somewhat pear-shaped, being about two feet wide at the bottom and one foot at the top; it is built entirely of clay, so that a couple of men can finish its erection in a few hours, and have it ready for use the next day. There is an opening in front about a foot in height, which is built up with clay at the commencement and broken down at the end of each operation. The bellows are usually made of goat's skin, which has been stripped from the animal without ripping open the part covering the belly. The apertures at the legs are tied up, and a nozzle of bamboo is fastened in the opening formed by the neck. The orifice of the tail is enlarged and distended by two slips of bamboo. These are grasped in the hand, and kept close together in making the stroke for the blast; in the returning stroke they are opened to admit the air. By working a bellows of this kind with each hand, making alternate strokes, a pretty uniform blast is produced. The nozzles of the bellows are inserted in tubes of clay, which pass into the bottom-corners of the temporary wall in front. The furnace is filled with charcoal, and a lighted coal being introduced before the nozzles, the mass in the interior is soon kindled.

"As soon as this is accomplished, a small portion of the ore, previously moistened with water, to prevent it from running through the charcoal, but without any flux whatever, is laid on the top of the coal, and covered with charcoal to fill up the furnace.

"In this manner ore and fuel is supplied, and the bellows are urged for three or four hours, when the process is stopped: the temporary wall in front being broken down, the bloom is removed by a pair of tongs from the bottom of the furnace. It is then beaten with a wooden mallet, to separate as much of the scoriæ as possible from it, and while still red-hot, it is cut through the middle, but not separated, in order merely to show the quality of the interior of the mass. In this state it is sold to the blacksmiths, who make it into bar iron. The proportion of such iron made from 100 parts of ore is about 15 parts."*

From this iron the celebrated wootz steel is made by the natives of India in a manner equally rude and primitive. But their production has no superior, if it is equalled, and for the purpose of fine cutlery it is infinitely superior to the best English cast steel.

The Damascus blades, so renowned even in the Middle Ages, and still so much sought for by military men, are produced from ingots, like those of wootz, which come from Golconda. They are small and oblong, and when cut in two form two swords.

The blast-furnace for the production of pig iron does not seem to be of ancient invention. Though the air or wind furnaces of the early Britons produced cinder in abundance, and perhaps as full of iron as the scoriæ of wootz, the iron obtained from both was malleable. It does not appear where or when the blast-furnace was first made use of; but the frequent irregularity of the ancient forges or the present bloomery would naturally suggest the use of cast iron for many uses, since it often happens that these forges become deranged through the change of workmen, ores, or some other cause, and "pot-metal" is produced, which, of course, may be cast in almost any form by remelting, and can only be reduced to wrought iron by reheating, and the process used in bloomeries to reduce pig iron to bar. This, however, is not the invariable result of "green hands" or derangement. Sometimes nothing but a mass of cinder or "burned iron" is produced, of no value.

Whatever might have been the ancient mode of producing iron,—by the wootz oven, the wind-furnace, the Corsican hearth, or the Catalonian forge, the *forges allemandes* of the French, or the *Stuck-ofen* of the Germans,—the mode most general in use during the modern ages and up to the present time, for the production of wrought iron direct from the ore, is that of the Catalan forge, and improvements on the same.

* Dr. Ure's Dictionary of Arts, Manufactures, and Mines.

All other ancient methods of which we have any definite knowledge produce less iron from the same quantity of ores, and at a greater expense of labor.

The Corsican hearth produces a very soft, malleable iron, but a little steely. Four workmen are required at one forge. The product of their labor is only four hundredweight of iron from ten hundredweight of ore, and twenty hundredweight of charcoal

FIG. 176.

ANCIENT IRON-MASTER.

mingled with wood of beech and chestnut, or about 40 per cent. from rich ores containing 60 to 70 per cent. metallic iron.

The yield of the Catalan forge is much greater from the same amount and character of ores, with less labor and fuel. Two men attend each forge, and produce four to five hundred pounds per day, with an equal amount of charcoal, and double the amount—or eight to ten hundredweight—of rich magnetic ores.

With good hematite ore, of about 50 per cent. average yield, a good blast and fair charcoal, two good workmen will produce four hundred pounds of iron per day; but their average production will be about 300 pounds.

The common Catalan forge, or bloomery in general use, is usually a rude structure of coarse masonry, built without any regard to the economy of fuel, ore, or labor. If properly built, and operated by careful workmen, double the usual results might be produced.

As before stated, the exact date of the discovery of the use of cast iron cannot be definitely fixed. According to Dr. Percy, the first cannons of cast iron were manufactured in Sussex, in England, by Ralph Hogge, in 1543. But Hogge was assisted by a Frenchman named Peter Baude, who, it appears, had learned the art of producing cast iron in France. Hogge, assisted by one of his servants,—Johnson by name,—afterwards made cannon of 6000 pounds weight.

Agricola, who died in 1555, wrote that "iron, smelted from iron-stone, is easily fusible, and can be tapped off."

The elevation of the bloomery into the blast-furnace appears to have been first accomplished in England. It was probably in the early part of the sixteenth century. Mushet, however, concludes that the old blast-furnaces of the forest of Dean were erected in 1550.

Up to 1621, charcoal was used exclusively in the blast-furnace. But about this date Lord Dudley obtained a patent for smelting iron with mineral fuel. It was not, however, much used until the discovery of its conversion to coke in 1730–35, when Abraham Darley, of Colebrook Dale, first used coke with success in the blast-furnace. But in

1740 during the change from charcoal to coke, the production of the English furnaces fell from 180,000 to 17,500 tons per annum.

The best yield of an improved and well-built blast-furnace, using charcoal with hot-blast, is one ton of pig metal to every three cords of wood or 120 bushels of charcoal. But we have seen many instances where ten to thirteen cords of wood were used to produce a ton of iron in the rude Southern blast-furnace, and one instance where *thirty cords* were used!

In the first case, where 120 bushels of charcoal are produced from three cords of wood, the charring or "coaling" is done in kilns, and 40 bushels of coal produced from one cord of wood; but in the second the coaling is done in open "charcoal pits," in which an average production of 33 bushels per cord is considered a good yield, particularly when a limited number of "pits" can be coaled on the same "hearth."

This expenditure of fuel is simply in the production of pig metal: to reduce it to bar iron nearly a third more coal is consumed than in the elaboration of the pig. That is, if 120 bushels produce one ton of cast metal, it will require 180 bushels to convert the metal to malleable iron under the same degree of improvement. But if it requires 333 bushels of charcoal to produce a ton of metal in the rude mountain-furnaces, it generally requires 500 bushels to elaborate the metal into bars under the same rude style of manufacture.

Under these circumstances, the improved Catalan forge is equal to the blast-furnace. But as improvements in the blast-furnace are now far in advance of the ancient forge, and likely to remain so, any comparison must be unfavorable to the latter, except in peculiar localities.

Fig. 177.

THE CATALAN FORGE.

DESCRIPTION.—*a* is a "loup," or bloom of iron forming under the blast of the tuyere; *b* is the cinder run off through holes provided rather above the bed of the loup; *c* is the tuyere, through or in which the nozzle of the blast-pipe conveys the blast to the hearth; *d* is the "boot," or leather pipe to which the nozzle is attached, and is movable at pleasure.

The hearth in which the loup lies is generally about twenty-four inches deep, but about ten inches of the bottom is filled with charcoal dust, or brasque, in which the loup is formed. The diameter of the hearth—which is nearly square—at the top is 20 inches in a line with the blast and 16 inches across the hearth. It is about 14 inches deep to the bed of the loup, and from 16 to 18 inches in diameter at the bottom. The forge represented above is superior in finish and style to those in general use. The cast-iron door is but seldom seen.

THE CATALAN FORGE.

The production of iron involves scientific questions of great and absorbing importance; but it is scarcely possible for a pure philosopher, inexperienced in the art of elaborating the metals, to render much assistance to the improvement of their manufacture. Nor is it likely that the merely practical can add to our knowledge in this art, except by accident. Intelligence and experience are both required in this most important branch of industrial skill, not for the purposes of invention and improvement only, but to conduct successfully the elaboration of the metal from the ore. Experiments in the manufacture of iron are costly, and ruinous in the event of failure. Even the most practical and intelligent hesitate to adopt theories, though ever so plausible and promising, because the risk is great and the danger of failure imminent, though the principle involved may be correct.

For instance: the pneumatic mode of decarbonizing pig metal, or the conversion of cast iron into steel, was at first considered a failure; and in this country, where the invention appears to have been first made, there was neither intelligence nor confidence enough to appreciate its merits. It is now, however, an established fact; and the probability is that the success of the invention will force us to pay tribute to the intelligence of England, as we have done in the past.

Yet there is as much room and opportunity for improvement in the production of iron direct from the ore as in the elaboration of iron and steel from the pig. The process in common use has been but little improved since the Middle Ages. The mountain-forge of to-day is much the same as it was five hundred years ago in Catalonia. We can see the opening for improvement,—the principle which requires development; but the mechanical difficulties have not yet been overcome.

The treatment of the ores in the Catalan forge involves—first, their deoxidization, and second, their reduction, or conversion to iron.

The ore is first selected in the mine or quarry. All silicious and earthy portions are rejected; and it often happens that there is more rejected than selected,—though the refuse may be good ordinary ore and fit for use in the blast-furnace. The picked ore is then laid in kilns, or large pyramidal piles, intermixed with brush, logs, or charcoal brasque, and "roasted" for several days. This torrefaction of the ores expels the moisture, and, to some extent, whatever sulphur or phosphorus it may contain, and reduces it to a friable, crumbling mass, which is readily pulverized by hand with a large, flat hammer or by machinery. It is always reduced to a powder before admittance to the hearth, in our mountain-forges; but in some parts of Europe the roasted ore, in small particles, is laid in the "*cruset*" or hearth, opposite the tuyers, and on the bottom of the hearth. We have never seen this practised here. Our forge-hands fill the hearth with charcoal, and when fully ignited the coal is covered with pulverized ore, which is thrown on with a peculiar flirt, so as to scatter it evenly over the glowing fire. Coal and ore are constantly added for about two hours, or until a loup is formed in the hearth. This is then manipulated and tried by the tools of the workman, and the cinder let off, when above its face. In from three to four hours the loup of iron and scoriæ acquires the proper size. The blast is then shut off, and the ball drawn out of the hearth. It is generally held on its edge and pounded with a wooden maul, to partially drain off the cinder, before it is taken to the trip-hammer. Here the loup is dexterously handled by the hammer-man until it is drawn to an oblong and square-sided "bloom" of about two hundred pounds weight. The forge-man is generally his own hammer-man, and when the iron is sold in the shape of blooms this part of the operation occupies but a small part of his time. But when the bloom is drawn into horse-shoe bars the work is laborious, though the production is not materially altered in either case, since the ope-

ration of deoxidizing the ores is progressing during the hammering process. While keeping the forge-fire in full blast for the purpose of reheating the bars drawn from the bloom, pulverized ore is frequently sprinkled over the mass of glowing charcoal. This answers a double purpose: first, it produces a protecting coat of silicious and fluid matter, which prevents the bar from burning, and, second, the ore is being prepared to form the next loup. Therefore, but a comparatively small amount of time is lost during the reheating and hammering process, as the common forges are operated.

FIG. 178.

IMPROVED FORGE AND BLOOMERY.

DESCRIPTION.—*a*, hearth, similar to, but larger than, the common Catalan hearth; *b*, boot and tuyers; *c*, fireplace for wood, coke, or mineral coal; *d*, heater for decarbonizing loups, when necessary, and reheating blooms to be drawn under the hammer or the rolling-mill; *e*, hopper for the introduction of charcoal to the hearth; *f*, hopper for the introduction of pulverized ore to the deoxidizer; *g*, flue under the deoxidizing hearth, which descends in steps towards the reduction hearth; *h*, deoxidizing hearth.

IMPROVED FORGE AND BLOOMERY.

The forge here presented is rather novel in construction, and is a combination of several well-known processes. The chief feature of the Catalan forge is preserved,—that is, the hearth, which does not differ much from the hearth of the blast-furnace; but here the deoxidizing is performed much the same as in the blast-furnace, by the waste heat which escapes in the common forge.

This forge is double, and contains not only two hearths, but a reheating apartment, so that three sets of men can operate at the same time. The escape-heat from the bloomery also passes through the deoxidizers, and helps to sustain the heat in the hearths.

The ores being thoroughly deoxidized descend to the hearth ready for fusion before the blast, and here the heat is very great and the reduction rapid. Cinder is allowed to partially cover the loup; and while the ore is constantly added to the glowing mass above, the iron as constantly adds to the loup in the bottom of the hearth.

When the loups are withdrawn, they are turned over to the hammer-men and reheaters, who convert them into blooms, and reheat and draw them into bars, while the forge-men continue the production of loups. By this process, ten loups, of two hundred pounds each, can be produced by each hearth in ten hours, or from four to five

thousand pounds of iron can be produced per day by one of these improved forges and bloomeries with ten hands; while the saving in fuel is much greater in proportion than the saving of labor.

In the common Catalan forge, 100 pounds of iron from 50 bushels of charcoal is considered a good yield: it often happens that double this amount is used in carelessly-constructed forges. In the improved forge, from 15 to 20 bushels of charcoal will produce 100 pounds of iron; while from three to five cords of dry wood, according to the state of the weather and the condition of the furnace, are sufficient for reheating purposes.

Mineral coal of any character, provided it burns well, answers the purpose of wood for reheating, and a pure coke or anthracite-coal may be used in the hearth; but charcoal is preferred if good iron is required.

These forges are much less costly than blast-furnaces and rolling-mills for the production of bar iron; but they can be recommended only in localities where a small amount of capital only can be profitably expended, and where rich ores may be obtained, since no other kind can be successfully used. Magnetic oxides and pure hematites, or specular ores, are generally made use of. Lean or silicious ores, unless separated from their impurities, will not produce good iron in the Catalan forge.

WATER-BLAST.

When water is abundant, and the head and fall are of proper height, this is an effective and cheap mode of obtaining a small blast; but it is necessarily weak, and a high

FIG. 179.

Exit of th

WATER-BLAST.

EXPLANATION.—*a*, water, both in blast or air box and in the flume above; *b*, air-chamber over the water in the blast-box or air-chest; *c*, blast-pipes leading to the forge; *d*, flume leading the water from the dam to the "head;" *e*, air-suckers, four in number, into which the air is drawn, as indicated by the arrows; *f*, air- and water-pipe leading from the head into the cataract. The bottoms of the suckers are secured in a wide, heavy plank: when this is raised by the lever attached, the water from the flume rushes into the pipe *f*; but when it is lowered, the water is shut off. Where the pipe *f* communicates with the cataract *g*, an opening of about two inches is left. The air is also carried into the cataract at this point, and down into the air-chamber, from which it cannot escape, owing to the force or weight of the water, which falls continually into the chamber and escapes by a vent in the end of the box.

pressure cannot be obtained with economy. For the rude Catalan forge, where only a limited blast is required, and where the expenditure of capital is also limited, perhaps this mode is the best that can be adopted, since its construction is simple and at a cost of a few dollars only, and it is not liable to get out of order. But when water is scarce or a strong blast required, the power can be economized by almost any style of blowing machinery.

The Catalan forge requires a blast of about one pound to the square inch. The common fan-blower will not produce this force of air; but most of the improved ones will, and, for the purpose of producing blast for such small operations as the mountain-forges generally are, no expenditure of power can be more effective. For the improved forge this mode can also be recommended, since the air-pressure required is not greater than one pound to the square inch.

PATENT FORGES AND FURNACES.

A great many patents have been granted in this country and Europe for the production of wrought or bar iron direct from the ore, but none of them have obtained popularity. The principle on which all these patent modes are based is the deoxidization of the ores by the waste heat from the hearth where the ores are reduced.

The Harvey patent in this country is as near perfection as any other with which we are familiar, and differs from the improved forge and bloomery, illustrated in figure 178, chiefly in having a puddling hearth in place of a Catalan hearth, in which to convert the ores to metal by the puddling process.

Good iron can be produced at reasonable expense in this furnace, but rich ores are required, and the quantity of fuel and labor is greater in proportion to the iron produced in General Harvey's furnace than in the blast-furnace, and the subsequent elaboration of the pig in the puddling and rolling processes.

If the same ores are used in the blast-furnace, of course the yield will be in proportion to the richness. The only real advantage we can discern in the Harvey patent is in the application of the fuel. Using rich ores, good iron can be produced with almost any kind of fuel capable of producing a strong heat,—for instance, pine-knots, charcoal, coke, bituminous coal, or anthracite, and perhaps hard, dry woods. But in the blast-furnace superior iron can be produced only with pure fuel, and the best only with charcoal. In this respect, the improved forge and bloomery, illustrated in figure 178, has perhaps less merits than the Harvey furnace; but the rapidity and simplicity of the operation in the former entitle it to equal consideration. In regard to economy, however, neither can compete with the modes now generally in use; that is, by means of the blast-furnace and subsequent puddling process, with rolling-mills for the elaboration of the bar from the pig.

As before observed, these furnaces can only be used economically under peculiar circumstances for the production of superior iron when charcoal cannot be obtained for the purpose. Yet we think it possible that the principle involved is susceptible of great improvement, and that a more economical mode may be developed by mechanical ingenuity, and the wonderful effects of the application of fuel by the Siemen's process —a comparatively recent invention—seem to point out the means; but, as neither space nor inclination will permit us to indulge in theories, we must leave this matter to the development of time.

THE BLAST-FURNACE.

In our improved charcoal hot-blast furnaces three cords of dry oak or pitch-pine wood will produce a ton of pig metal; but in the cold-blast furnace, with the same degree of perfection in mechanical construction, and the same skill in conducting the operations, five cords of wood are required to produce the ton of iron.

In France, where great economy is practised in the use of fuel, one ton of charcoal produces a ton of pig iron; while two tons, or double the amount, of charcoal are required to elaborate the pig metal into bar iron,—requiring, thus, three tons of charcoal to each ton of merchant bar.

The proportion is rather less when mineral coals are used. Two tons of coal—mostly bituminous—or coke are used to the ton of pigs produced; while only three tons, or one-third more, are used to elaborate the pig metal into bar iron, being five tons to produce the merchant bar from the ore.

But in the ordinary charcoal blast-furnaces, taking the average of such in the Southern States, for instance, the production of iron is much less to the amount of fuel used. The best yield we know of in Virginia and Alabama is about one ton of pig iron to five cords of wood; but, since the charring is done there in open pits, not more than thirty-three bushels of charcoal is obtained from a cord, or 165 bushels from the five cords of wood used. This, however, is the most favorable result: we have seen thirty cords of wood used to produce a ton of pig metal in Alabama; but from eight to ten cords to the ton of iron produced is about the average. To reduce the pig metal to bar, not less than ten additional cords are used. Therefore, to produce bar iron from the ore, by the process of blast-furnace and bloomery, not less than an average of eighteen to twenty cords of wood, or about six hundred bushels of charcoal, per ton of bar iron produced, is required; which is double the quantity used in our improved furnaces, or in the furnaces of France, and considerable more than is used in the improved forges for producing iron direct from the ore.

FIG. 180.

THE BLAST-FURNACE.

DESCRIPTION.—*a* is the throat; *b*, *b*, the flues; *c*, *c*, top of the boshes; *d*, *d*, the tuyers; *e*, *e*, fluid cinder in the hearth; *f*, *f*, fluid iron in the hearth.

PRINCIPLE AND OPERATION OF THE BLAST-FURNACE.

Figure 180 represents the interior of the blast-furnace. The form is that which is general where anthracite coal is used as a fuel. The height and diameter of these anthracite furnaces vary considerably. The most available dimensions are twenty feet diameter above the "boshes," by fifty to sixty feet in height. The dimensions and form of the hearth are matters on which but few "founders" agree. There can be no doubt, however, in regard to the two most important considerations; first, the hearth should never be too wide to admit the passage of the blast to its centre; and second, it should always be deep enough to prevent the exposure of the fluid metal to the action of the blast. In a furnace of twenty feet bosh, the hearth should not be less than five nor more than seven feet deep.

The form of the hearth we think of more importance than is generally accredited to this item in the construction of furnaces.

FIG. 181.

HEARTH.

EXPLANATION.—a, cinder run; b, temp, or tap; c, c, c, tuyers.

Figure 181 represents the general form of hearth, which answers the best purpose in practical operation. It is not important, however, that it should be precisely like the diagram, since it may be parallel, elliptic, or oblong, with the corners rounded in all cases. In a furnace of twenty feet bosh, this hearth should be from 2 to 2½ feet wide, and from 10 to 12 feet long. The bottom of the boshes should conform, of course, to the general form of the hearth.

The advantages of this style of hearth are several: the blast penetrates beyond the centre, and may be made to reach nearly to the opposite side; the tuyers enter from opposite sides the entire length of the hearth, and the blast is evenly distributed; there is less danger from "scaffolding," and the burden comes down more regularly.

The height of the boshes will depend on their slope. An inclination or angle of 75° to 80° may be used in anthracite furnaces; but in coke, bituminous coal, or charcoal furnaces, the angle ranges from 45° to 75°. The walls or body of the furnace reach from the top of the boshes to the bottom of the flues. The height of this portion depends on the depth of the hearth, the slope of the boshes, and the position of the flues. In furnaces of this size, about 20 feet is the common elevation of the body from the boshes to the flues, or from one-third to one-half the height of anthracite stacks generally. In all old furnaces the walls inclined from the boshes to the throat, or the body had the form of a bottle, the neck answering to the form of the throat, with a gradual decrease in diameter from about the middle to the top. But in all well-built and successful anthracite, and perhaps we might include all kinds of furnaces, the body is of nearly equal diameter from the boshes to the flues, or with but a slight decrease towards the top.

The flues are distributed around the top of the furnace, between the body and the mouth. The whole space may be denominated the "throat," though that term is generally applied to the mouth or head. The height of this portion is from 8 to 10 feet; and in this distance the diameter decreases from 18 or 19 feet to 6 feet. This part of modern furnaces has an important part to perform in the operations of smelting. The increase in diameter from the throat or head to the flues admits of the expansion of the materials or charges, which are thrown in cold, and their enlargement between these points is considerable; while the decrease in diameter from the body to the throat acts as a check to the ascending gases, and diverts them through the flues to the steam-boilers and hot-air chamber,—aided, however, by the draft through the hot-blast chimney.

The principal gas which escapes from blast-furnaces is carbonic oxide, which is composed of one equivalent of carbon and one of oxygen. This gas, when combined with a certain amount of air, burns with great heat, and furnishes a sufficiency of caloric to generate steam for the operation of the blowing-machinery, and to heat the air thrown into the furnace from 600° to 1500° of temperature, according to the mechanical arrangement of the hot-blast oven.

The blast-furnace on a grand scale is worthy of admiration, and is one of the most magnificent spectacles offered by our industry; and, while simple in appearance, its successful and economical operation demands, perhaps, more experience and intelligence than any other pursuit of man, if we consider the progressive development of the principles involved and the improvements desirable and perhaps attainable.

SMELTING OPERATIONS.

The proper mixture of the ores, coal, and flux, depends on the quality of the materials used. If the ore is rich and pure, and the coal free from slate, bone, and sulphur, only a comparatively small amount of flux is required. But if the ores are refractory and silicious and the coal indifferent, a larger amount of both coal and flux is necessary.

With a burden of magnetic and hematitic ores, yielding an average of fifty per cent. of metallic iron, two tons of ordinary anthracite and one and a half of flux or limestone are required in the generality of our anthracite furnaces. In a few instances from two tons and a quarter to two tons and a half of coal are used; but there are furnaces on the Hudson in which less than one ton and a half of anthracite is used to the ton of pig produced, with about the same proportions of ore.

We have assisted in the management of a furnace using hematitic ores alone, but from various localities and with a small percentage of manganiferous hematites, in which one ton and a quarter of anthracite produced a ton of pig iron as an average of six months' operation.

The secret of this difference in the amount of fuel used does not lie in the character of the ore or the purity of the coal alone, but in the construction and operation of the furnace, as well as in the items of coal and ore. An admixture of ores even of one class, though from several localities, reduces the quantity of flux and economizes the cost of reduction; but a small quantity of manganese or manganiferous ores not only saves flux and fuel, but improves the make of iron.

A careful selection of the coal used is also an important item. The best coal used in our anthracite furnaces contains ten per cent. of silicious matter, and much of it not less than fifteen per cent. of incombustible impurities. The bone and slate not only will not burn, but they require an equal amount of carbon to reduce them to a fluid state, and the same equivalent of lime to flux them. Therefore ten per cent. of impurity in coal adds thirty per cent. to the quantity of coal and lime required. It would be better to take the time necessary to examine the coal and separate it from the bone and slate, as far as possible, than to feed it to the furnace as it comes from the mines.

The larger the amount of earthy or silicious matter the coal, ores, and limestones contain, the greater will be the amount of flux and fuel required.

In regard to the construction of the furnace there are several important objects to be aimed at. The hearth should be deep enough and large enough to hold the metal for twelve hours, or a fixed period, beneath a protecting cover of fluid cinder, and below the direct influence of the blast; but it should not be so deep as to allow the "melting zone" to fall below the tuyer on running out the metal at "casting." Nor should the size of the hearth be so great as to prevent a blast of five pounds' pressure per square inch from reaching beyond its centre. In order to meet all these requirements, an oblong hearth is most desirable; and, to allow of the prepared burden coming freely and regularly to the melting zone, the lower part of the boshes should also have an oblong shape to conform to the style of the hearth.

The body of the furnace should be as large and capacious as possible to be in uniformity with the bosh and the flues. It does not seem desirable that its dimensions should increase above the boshes, because it is supposed that the expansion of the materials only reaches the maximum at that point, and the regular descent of the charges and ascension of the gases depend on the open condition of the mass and its freedom from all liability to jam from expansion or from contraction of area of the body of the furnace. The greatest expansion takes place between the throat and the flues, but the heat does not increase in proportion below that point until the boshes are reached; and the expansion cannot be great below the flues. Yet for the free descent of the ores it is supposed that the body should increase slightly in diameter from the flues to the top of the boshes.

Truran, an eminent English founder and engineer, argues strongly that the best form of furnace is that of a gradual increase in diameter from the hearth to the throat. His experience entitles his opinions to respect; but we have not heard that his views have been practically demonstrated, though experiments were in progress over ten years ago by Mr. Coleman, of the North Lebanon furnaces, who erected a stack on Truran's plan. It did not, however, produce successful results; but we are informed the difficulty was not in the stack or plan, but in some minor details of blast and machinery.

The benefits arising from a large area in the upper part of the boshes and the body of the furnace are several. It admits of the ready escape of the products of combustion by affording space for their ascent, and an open condition of the burden to admit a free passage.

The longer the mass of ores are exposed to the escaping heat and carbon, the longer will they be subject to torrefaction, oxidization, and carbonization, and, consequently, the better prepared on arriving at the point of fusion to be reduced or separated from their earthy impurities.

Truran says there should be no escape or waste of carbon; that it should be entirely taken up by the ores in the body of the furnace, and that the gases which now escape or are used under the boilers and in the hot-blast oven really constitute "waste heat," and could be put to a better purpose in preparing the ore than in generating steam or heating the blast.

It seems probable that such a consummation would produce economical results; but the difficulty lies in the application and mechanical construction of the furnace. The common theory is that the escaping carbon unites with the oxides of the ores and forms carbonic oxide. It does not appear, however, that the carbon of combustion unites with the oxides of the ores for their expulsion. It may expel the oxide by taking its place, thus forming a carbide of iron. If it necessarily unites with the oxide in order to deoxidize the ore, we cannot understand why the quantity of oxygen should be diminished by the process, since the carbonic acid of combustion is changed to carbonic oxide in ascending through the furnace.

In the economy of combustion the fixed carbon of coal is not consumed or destroyed, but reduced from a solid to a vapor or gas, in combination with the oxygen of the blast, forming carbonic acid, which consists of one equivalent of carbon and two of oxygen. In passing up the furnace, through the coals, this carbonic acid loses part of its oxygen and becomes carbonic oxide. It is, therefore, impossible that the vapors of combustion should affect the deoxidization, since the volume of oxygen is reduced instead of increased in ascending through the furnace. The coal, therefore, which comes in contact with the ores must absorb the oxide of the latter, while the ores absorb part of the carbon of the former, and both are thus improved thereby. The coal is better prepared for combustion, and the ores for reduction.

We do not pretend to be experts in the science of chemistry, and our arguments may be fallacious; but such appears to us to be the operations going on in the body of the furnace.

The carbon of the coal, expanded by heat to many hundred times its original bulk, and the entire amount of air thrown into the furnace by the blast, also vastly expanded, must escape in vapor; but neither the one nor the other is destroyed. They return again to the earth and the air through the chemical agencies of nature, which operate constantly. Heat rarefies them, but cold condenses them.

It would appear, therefore, that the greater the mass of coal and ore through which the "waste heat" of furnaces is diffused, and the longer they remain in contact, the greater will be the quantity of oxide extracted, and the greater the quantity of carbon absorbed by the ore. But it is not probable that the vapor of carbon—arising from the combustion of coal before the blast—should carbonize the ores or unite with their oxides in our present blast-furnaces, since carbon, in combination with oxygen or

hydrogen, can be reduced from a vapor to a solid only by intense cold or great pressure, or both combined. The vapor of combustion in ascending through the furnace changes from carbonic acid to carbonic oxide, and must lose a portion of its oxygen in the process. If it took up the oxides of the ores, this could not happen, since the volume of oxygen would be increased; but, on the contrary, we find it decreased.

Combustion does not take place above the zone of fusion, or beyond the direct influence of the blast, in smelting-furnaces, and this region cannot extend much above the hearth. The product of this zone is carbonic acid gas, which extinguishes combustion; therefore neither the carbon of the coal nor the oxide of the ore can be consumed or vaporized when in contact with this gas; and, since it arises immediately from the zone of fusion, these processes cannot go on except when under the direct influence of the blast. Therefore the ores which are not deoxidized by the coal must be deoxidized at the expense of the burning carbon at the point of fusion.

But carbon will absorb oxygen when in contact under a certain degree of heat, even when combustion cannot take place; and if pulverized charcoal or anthracite and iron ores are mixed in a close vessel, and subjected to a strong heat, the carbon will absorb the oxide of the ores, while the ores will absorb a portion of the carbon of the coal.

We all know that pure iron, which contains no oxygen, will absorb carbon and become steel when packed in the cementing furnace with charcoal dust, and subjected to a strong heat, though air is carefully excluded from the cementing chest.

These facts demonstrate that the deoxidization and carbonization of the ores in the blast-furnace are the result of contact with coal under a high temperature; but they also produce conclusive evidence that these processes furnish but little of the "waste heat," so called, or the gases escaping from the blast-furnace. The vapors of combustion, arising from the zone of fusion, and produced by the oxygen of the blast and the carbon of the coal, produce all or most of the gas which we call "waste heat," and furnish the means of propelling the blast-engines, and adding caloric to the air thrown into the furnace. These vapors must escape, and though much of the caloric they carry off may be retained by Truran's suggestions, and employed in the torrefaction of the ores and the increase of temperature in the body of the furnace, the volume of gas would not thereby be diminished. The equivalents of carbon and oxygen might be slightly changed, but the gases which we utilize now so successfully would still escape, even though the flues were comparatively cold.*

The benefit arising from an enlarged area in the body of the furnace is, therefore, due to the longer period given for the preparation of the ore, and perhaps we may add, the coal.

When the coal and ores are fed into the furnace in large masses, as at present practised, the period required for full deoxidization and carbonization is much longer than the rapid consumption of the charges will allow, and the ores arrive at the point of fusion only partially prepared for reduction. At this point the deoxidization can take place only at the expense of both oxygen and carbon, or blast and coal.

If allowed to remain longer in contact, the coal would absorb a larger quantity of the oxides of the ore, and the ore would extract a larger quantity of the carbon of the coal.

The extraction of the oxides from and the addition of carbon to the ores prepares them for rapid reduction with but a small amount of caloric; while the absorption of the oxides of the ore by the carbon of the coal prepares the latter for combustion on

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* We are led to this conclusion by the fact that the waste heat or vapor of carbon will not deoxidize iron ores on the reverberatory hearth. In all the processes for producing wrought iron direct from the ores, it is necessary to mix pulverized coal or charcoal with the pulverized ores. The vapor of carbon may be produced from coal without the direct use of oxygen by subjecting it to a strong heat; but it does not appear that such vapor will carbonize iron ore. This can only be done by the unburned carbon in contact with the ores under a strong heat. Still it is possible that some of the "waste heat" may be produced from both the carbon of the coal and the oxide of the ores under the high temperature of the furnace.

arriving at the point of fusion, and diminishes the quantity of air required otherwise for that purpose.

ACTION WITHIN THE BLAST-FURNACE—FUSION.

The contents in the boshes and near the hearth, being raised to an intense heat by the combustion of the fuel, are reduced to a pasty condition; the limestone parts with its carbonic acid some distance above its point of fusion, but the lime is more readily fused than the ore, and commences to flow earlier than the earthy ingredients of the ore; with these, however, it combines, aids their fusion, and forms with them a liquid slag or cinder. This flows from the lower part of the boshes to the hearth, while the oxidized ore, partially free from its silicious or earthy parts, on arriving before the blast is reduced to a liquid metal and falls through the cinder in drops or small streams. Any remaining earthy matter is taken up by the flux during the passage of the iron through it. The metal, being heavy, remains in the bottom of the hearth, while the flux or slag, being lighter, floats on the top of the iron.

The cinder is allowed to flow almost constantly from the top of the hearth, while the metal is tapped off occasionally, or about once every twelve hours.

The slag indicates by its appearance the manner in which the furnace is working. Thus, if the cinder is liquid, nearly transparent, or of a light-grayish color, and has a fracture like limestone, a favorable state of the furnace is indicated. Tints of yellow, blue, or green show that the furnace is working cold. A deep brown or black color indicates that the supply of fuel is not sufficient to deoxidize the ore, or that the ore and coal have not been in contact a sufficient length of time for the purposes of deoxidization and carbonization.

THE ECONOMY OF SMELTING.

Instead of altering the form and increasing the body of the furnace, a better plan is to prepare the ore for a more rapid and complete deoxidization and carbonization; and this can be done with much economy by a simple process.

The objection to an increase in the height of stacks, to the increase in area, and the pulverization of the materials used, is the strangulation of the draft, or the obstruction to the free escape of the vapors of combustion; but this is provided for, while the preparation is completed by the following process:—

All ores should be torrefied in kilns before going into the furnace; and this can be done at a very trifling expense with the waste coal of the anthracite mines, if proper provisions are made for the purpose. The cost of this operation in kilns with waste coal is not over ten cents per ton, while that of torrefaction in the furnace, by our present process, is not less than one dollar per ton of iron produced at present prices.

When the ore is thus prepared, the deoxidization and carbonization are rapid, and though the ore may pack more closely in the furnace and obstruct the draft to a certain extent, the furnace-stack may be much less in elevation, and better results be obtained, than in the high furnaces where the torrefaction is carried on at the expense of the production of iron.

In Wales, where iron is made cheaper than in any other part of the world, this preparation of the ores is always carefully performed; and we may also practise it with equal economy here.

But it is not proposed that the improvement should stop at this point, since still greater economy can be effected by carrying the preparatory process further.

The most refractory and massive ores after torrefaction become friable and easily pulverized: they are therefore readily reduced to a powder by the stamping or rolling process. In this condition they are mixed with a sufficient amount of fine coal or carbon dust, to absorb the oxides of the ores and carbonize the iron. In fact, enough carbon

in the shape of powdered anthracite may be added to complete the fusion as well as the preparation. To the pulverized ore and coal is then added a sufficient quantity of lime to insure adhesion and for flux: the mass is then made into a stiff mortar, and subsequently into blocks by hand or machinery.

This process may seem elaborate and costly; but from the burning of the ore to the formation of the blocks ready for the furnace, not over twenty-five cents per ton need be expended in labor, if the proper apparatus and machinery are provided.

It can always be made convenient to dump the ores at the top of the calcining kilns, while the elevation of the calcined ores to the top of the pulverizing and preparing establishment—something like our anthracite coal-breakers, but less extensive—can be done by the ordinary means. From this elevation the pulverized ores, coal, and lime descend to the mixing-troughs, and from them to the compressing machines, where the compound is formed into blocks solid enough for handling, and from whence they are conveyed by self-acting elevators to the top of the furnace, to be stacked and dried for use.

By this mode one ton of waste coal, such as is now refused and is a constant trouble and expense to our coal-miners, would be of more service than two tons of the best anthracite lump as now used in our blast-furnaces.

THE HEARTH.

As stated and demonstrated, the ores and coal of the blast-furnace should descend to the hearth in a condition for instant fusion. If they arrive in this condition before the blast, the amount of coal required to reduce the carbide to fluid metal is limited, and the process rapid. The iron falls like rain through the liquid cinder, which covers and protects it against reoxidization by the oxygen of the blast. The lighter materials, such as silica and all earthy substances, arise to the surface and are taken up by the flux. That is, the lime unites with the silica, &c. to form cinder; the carbon unites, to a limited extent, with the iron, and forms cast iron; while the liberated carbon of the coal, united with the oxygen of the air of the blast, escapes as the vapors of combustion.

If the fluid carbide of iron in the hearth of the furnace was not protected by the covering flux or cinder, it would be reduced by the action of the blast, first to a malleable iron, and then again to the oxide of iron, in the shape of a black magnetic oxide, similar to the scales which lie around the blacksmith's anvil.

THE CONVERSION OF CAST METAL INTO BAR IRON.

The conversion of the cast pig, which is the production of the blast-furnace, into bar or malleable iron, is a more costly and laborious operation than the first process, or that of reducing the oxide of iron to the carbide of iron or cast-iron.

The decarbonization by the process of puddling and oxidization is more costly and troublesome than the deoxidization and carbonization in the blast-furnace, excluding the cost of the ores. That which is first done to produce the pig must be undone to produce the bar. It would thus appear that the proper process would be to produce the bar direct; but to the present time we have failed to do this with as much economy as it can be done, indirectly, in the blast-furnace: we think, however, the difficulty is merely a mechanical one, and that its accomplishment is within the scope of modern invention.

IMPROVEMENT IN HOT-BLAST OVENS.*

"On the Practical Results obtained from Blast-Furnaces by the Use of Hot Blast of a very High Temperature."

One of the most valuable papers read before the British Association at its meeting this year was one by E. A. Cowper, on the subject above stated. It will be seen that the blast is heated by a cellular mass of brick-work, on the principle of Siemens's furnace.

This plan of obtaining an intense heat is destined to play a great part in the arts, and we wonder that it has not attracted greater attention in this country.

"It is not proposed to detain the meeting with a history of the numerous attempts which have been made to raise the blast for blast-furnaces to a very high temperature, nor will the author occupy much time in the description of the means by which the desired result has been obtained, as a full account of the apparatus was given at the meeting of this Association held at Oxford, though the paper on the subject was not printed in the Transactions.

"In 1861, experimental stoves only, on the new plan, had been erected and worked for heating the blast for one tweer out of the five used for one blast-furnace. Such satisfactory results were, however, obtained, that it was clear that the difficulty of procuring blast of a very high temperature had been overcome, and Messrs. Cochrane & Co., of Woodside Iron-Works, Dudley, and Ormesby Iron-Works, near Middlesboro'-on-Tees, forthwith erected large stoves on the new plan for a complete blast-furnace, and it is now proposed, with your permission, to lay before the section the results obtained during upwards of four years' practical working with these stoves.

"The effect of heating air on the new plan was that a temperature of blast of 1150° Fah. was obtained, instead of only 600° or 700°, as with cast-iron pipes in the common stoves. There was no loss of blast from leakage owing to cracked or damaged cast-iron pipes. The iron produced was of rather better quality; twenty per cent. more iron was made from the same furnace, and fully 5 cwt. of coke was saved in the blast-furnace per ton of iron made.

"The details of the construction of the new stoves will be readily understood by reference to the drawings.

"First. There are two stoves, which are heated alternately and used alternately in heating the cold air: these are filled with brick-work 'set open,' or with small spaces between the bricks, and form regenerators, on the principle of Mr. Siemens's 'regenerator furnaces,' as now so largely used in glass-houses, gas-works, iron-works, &c., both for obtaining great heat and economizing fuel.

"The outside of the stoves is of thin wrought-iron plate lined with fire-brick, the iron skin being necessary to retain the blast under pressure, while the fire-brick resists the heat.

"Second. There are provided for the purpose of heating the stove's valves, for the admission of gas and air into a central flue, where combustion takes place when a stove is being heated, the products of combustion passing up the flue and down through the mass of fire-bricks forming the regenerator, and escaping at the bottom to the chimney after the whole of the heat has been abstracted by the fire-bricks, the temperature of the chimney being from 212° to 250°, or thereabouts, during the time a stove is being heated, viz.: for a period of four hours. Then, when a stove is hot, the gas and air are turned off, the chimney-valve shut, and the cold blast is turned on at the bottom of the regenerator, and passes up through the bottom courses of brick-work in the regenerator,

* From the "Scientific American," vol. xiii., No. 21, New Series.

thus very quickly becoming heated; and passing in the heated state up through the remaining courses of brick-work, and down the central flue through the hot-blast valve to the blast-furnace, the process of absorption of heat by the air being so perfect that, as long as a few of the top-courses of the brick-work remain hot, the blast is well heated, the variation in the temperature of the blast being only about 100° Fah. with four-hour changes.

"Third. The gas for heating the stoves is supplied from gas-producers, similar to those commonly used by Mr. Siemens for his regenerating furnaces, and which have already been described before this Association. They consist of a simple brick enclosure or fireplace, with bars near the bottom, for the admission of a very small quantity of air. The gas is formed by slow combustion of a very thick fire, supplied with poor coal, or slack, down a slope, or hopper, the gas passing off from above the fuel through pipes to the hot-blast stoves. Gas may, however, be taken from the top of the blast-furnace for heating the stoves, provided proper arrangements are made to separate it from the dust which comes over from the blast-furnace with it; and, judging from recent practical experiments, it is certain that there are several ways in which this may be done with perfect success.

"The late James Beaumont Neilson, who did so very much for the iron manufacture by his original invention of the hot-blast in 1829, was sufficiently long-sighted to predict the advantages that would flow from the use of blast of a very high temperature, though, as it happened, he was limited to what could be obtained from passing the air through iron pipes exposed to a fire, as in common stoves.

"Mr. Neilson said, 'In the new regenerator ovens that had just been described, the great capacity of fire-brick for heat had been well taken advantage of, and a very important step in advance had been by giving the means of raising the temperature of blast much above the extreme limit practicable with the old ovens; and he considered this would be productive of the greatest benefit in the working of blast-furnaces. He had no doubt the make of iron would be considerably increased by the higher temperature of blast given by the regenerator ovens.'

"These anticipations have been fully borne out in practice during upwards of four years' regular working of the stoves. The high temperature of the blast produces such an improved effect in the furnace that the 'burden' is increased so as to save fully five hundred-weight of coke per ton of iron made; and as there is less fuel supplied, so there are less impurities taken in, and the quality of the iron is improved, the 'tweer-breasts' do not 'work hot' or burn, or give more trouble than usual, as the burden is increased as just stated. The same furnace is, of course, enabled to do more work, the 'make' being increased fully one-fifth: so that a given 'plant' produces 20 per cent. more iron per annum, besides saving nearly 3*s.* per ton for coke.

"There is less friction or loss of pressure of blast in these stoves than in common ones, and there is no loss of blast by leakage through cracked or burned cast-iron pipes or joints. More stoves are now being erected on the same plan."

Every practical iron-master will comprehend at once the economy and benefits of the foregoing plan of hot-blast apparatus. It is not only commended by the great increase of temperature produced, but by its simplicity, cheapness, and reliability.

Those who have had the most experience with the common hot-blast ovens, or "stoves," formed with cast-iron pipes, are familiar with their imperfections. It is impossible to construct a cast-iron heater that will give much over half the temperature of blast obtainable from the regenerator described.

But we are far behind our cousins across the water in the manufacture of iron and in the use of the new and wonderful inventions perfected within the last ten years. It is true, Siemens's regenerators are in use at Pittsburg; yet but few of our iron manufacturers know much or any thing about them. Their application to the production of bar iron direct from the ore will be considered further on.

THE PUDDLING-PROCESS.

The process of puddling, or the decarbonization of cast iron by stirring it while in a fluid condition and exposing all parts to an oxidizing current of flame and air in a reverberatory furnace, was invented in 1783–84 by Mr. Henry Cort, of Gosport, England. He also invented, about the same time, the use of rollers for the purpose of producing bar iron from the puddled blooms or balls.

"It is not, perhaps, generally known that Mr. Cort expended a fortune of £20,000 in perfecting his invention for puddling iron and rolling it into bars and plates, that he was robbed of the fruit of his discoveries by the villany of officials in a high department of the Government, and that he was ultimately left to starve by the apathy and selfishness of an ungrateful country."*

The process ot converting pig metal to bar iron in the puddling-furnace, as before stated, is the reverse of the processes employed to produce the pig from the ore in the blast-furnace. In the puddling-furnace the pig iron is reduced to a fluid condition by a strong heat. In this fluid state it is subject to currents of flame and air while agitated by the tools of the puddler. This brings the iron into contact with the oxygen of the air, which absorbs or burns out the carbon from the pig metal. In other words, the carbon unites with the oxygen and passes off as the vapors of combustion, leaving the iron in a decarbonized and crystalline condition. The crystals are elongated or drawn into fibres by the rolling or hammering process, and thus form malleable or bar iron.

In the puddling-process great care must be taken by the puddler to prevent the burning or oxidization of the iron when divested of carbon, which is done by constantly shifting the masses and immersing them in the fluid cinder of the puddling-hearth. The operation of puddling by hand is very laborious, and can only be done by experts without great loss. The stirring process should not be suspended an instant from the time the iron is in a fluid state until it is ready to ball, or is free from its carbon.

In the best puddling-furnaces, expert puddlers make six heats per day, of 4 cwt. to each heat, or 24 cwt. of pigs used, and 22 cwt. of puddled iron produced with an expenditure of 28 cwt. of coal in the single and 17 cwt. in the double puddling-furnaces to the ton of puddled bars made.

These are the results of the best English puddling-furnaces. We do not do as well at home with the best anthracite coal. The average consumption of coal in our rolling-mills is three tons to the ton of railroad bar produced; but this includes, of course, the reheating and rerolling of the puddled bars.

The total consumption of anthracite coal to the ton of railroad iron produced, from the ore to the rail, is an average of five tons, in this country. Where bituminous coal is used, the consumption is from six to seven tons per ton of rail.

PUDDLING IRON BY MACHINERY.†

"At the last meeting of the Mechanical Engineers' Society of Birmingham, a paper was read by Mr. Henry Bennett, of Wombridge Iron-Works, on puddling iron by machinery, from which we take the following extracts.

DESIRABILITY OF THE IMPROVEMENT.

"In the manufacture of wrought iron from the crude pig iron, the purifying of the

* Iron, its History, Properties, and Processes of Manufacture, by William Fairbairn, C. E., &c. &c., Edinburgh.
† From the Scientific American, vol. xiii., No. 19, New Series.

metal by the process of puddling involves a very heavy and long-continuous hard labor, since the metal, after being smelted in the puddling-furnace, has to be continuously stirred for a considerable time while 'boiling,' in order to expose it thoroughly to the action of the current of air passing through the furnace, so as to affect the chemical changes required for the separation and removal of the impurities combined with the iron.

"The metal has then to be 'balled up' into separate masses, of about three-quarter cwt. each, for the 'shingling' hammer; and the whole process extends over about an hour from the time of melting the pig iron for each heat, of which six are worked in the day.

"The application of machinery to puddling has been long felt to be very desirable, on account of the laborious nature of the process, owing to the continuous heavy work required, and the great heat to which the men are exposed; and the simple mechanical character of the greater part of the process, which consists in merely a continuous, uniform stirring of the material, renders it very suitable in that respect for the application of machinery. But the high temperature of the furnace and the necessity for not interfering with the current of air passing through it, which has to be regulated and changed as the process advances, cause great difficulty in successfully carrying out the application of machinery in place of hand-labor.

OBJECT AIMED AT.

"The object of the writer has been to employ machinery simply to aid the puddler, by relieving him of the most laborious part of the work, namely, the stirring or working of the metal in the puddling-furnace.

"At the same time, the objects aimed at have been, by a more rapid and uninterrupted process of stirring the metal to shorten the time of puddling, thereby economizing fuel; to improve the quality of the iron by rendering the process more uniform and perfect than with hand-labor; and to increase the yield of the furnace by working larger charges than could be both puddled and balled up at one heat by hand-labor alone.

DESCRIPTION OF THE MACHINE PUDDLER.

"The ordinary puddling-tool, or 'rabble,' is worked backward and forward in the puddling-furnace by a vertical arm outside the furnace, to which it is connected by a notch in the handle of the rabble, dropped loosely upon a pin at the bottom of the working arm. This arm is cottered at the top into a horizontal square bar overhead, sliding longitudinally through two guide-sockets, and worked by connecting-rods from a long T-iron bar extending horizontally across a whole row of puddling-furnaces, the T-bar being carried by anti-friction rollers. A longitudinal reciprocating motion is given the bar by a crank at one end driven by engine-power. The guide from, or sector carrying the guide-sockets of the sliding bar, is centred on a vertical pin immediately over the door of the puddling-furnace, and the outer end is moved transversely from side to side with a slow reciprocating traverse along a guiding quadrant by means of a connecting-rod from a crank which is driven through a worm wheel and screw shaft extending over the furnaces alongside the reciprocating T-bar. This bar works at a speed of about fifty strokes per minute, and has a length of stroke of 2 feet 10 inches, carrying the rabble with the same length of stroke across the floor of the furnace. The traverse motion given by the crank, which makes one revolution for every seventy strokes of the rabble, causes the direction of each stroke to change gradually between two extremes of the guiding quadrant, so that the end of the tool, instead of moving backward and forward

always in the same line, is worked successively over every portion of the floor of the furnace, within certain limits, in lines radiating from the working hole in the door of the furnace, corresponding exactly to the action in hand-puddling.

"In the double furnace with a door on each side, two traversing cranks are set at right angles to each other, so that the two rabbles are always working in different parts of the furnace. The whole of the machinery is kept clear above the furnace outside, and completely protected from heat, and quite out of the way of the men,—nothing being exposed to the heat except the rabble or puddling-tool, the same as in hand-puddling.

"The double furnace is exactly the same in construction in all respects as the ordinary single puddling-furnaces, except that it is made with a working door at each side, and is one foot wider inside.

OPERATION OF THE MACHINE.

"When the charge of pig iron is melted and ready for the commencement of the process of puddling, the apparatus is put in action by simply dropping the notch in the handle of the rabble, or the pin in the working arm, which is kept continuously in motion by the horizontal reciprocating T-bar working overhead. The puddler changes his tool from time to time, as it becomes heated, by simply lifting the notch in the handle off the pin in the working arm, and replacing the tool with a fresh one, without stopping the machine; and when the iron begins to thicken, he takes the opportunity of each change of tool to make a few strokes by hand, in order to collect the metal from the extreme sides of the furnace into the centre, which is found to insure the whole charge being uniformly worked. The usual time of working with the machine is about 25 minutes with ordinary forge pig iron, the tool being changed five or six times; but with gray iron the time of working is much prolonged.

"In the latter case the machine is especially serviceable, since the iron keeps in a fluid state much longer, and requires, consequently, so much more working; which causes the labor to be so much more severe in the case of hand-puddling that there is great difficulty in getting men to work any iron that is very gray. With the machine, however, this causes no increase of labor to the men, and only increases the time of the process.

"When the iron begins to thicken, or, as it is termed, 'coming to nature,' the machinery is disconnected without stopping it, by simply knocking out the cotter that fixes the upper end of the vertical working arm; the arm then drops out, leaving the furnace-door entirely clear for the puddler to ball up the iron, which is done exactly in the same manner as in ordinary puddling-furnaces, without the man being in any way inconvenienced by the machinery continuing to work overhead.

ECONOMICAL RESULTS.

"The machine is applied to ordinary single puddling-furnaces without any alteration being required in the furnace, the frame of the apparatus being merely attached to the top of the furnace. The double furnace is preferable, however, as it effects a great economy in the consumption of fuel as compared with a single furnace, and puddles double the quantity of iron in the same time. With the single furnace at the writer's works, and charges of 5 cwt., the consumption of coal is 28 cwt. per ton of puddled bar made; but with the double furnace, and charges of 10 cwt., the consumption of coal is only 17 cwt. per ton of puddled bar, being a reduction of 39 per cent. The number of heats or charges worked in the single furnace is six heats of 5 cwt. each, and in the double furnace five heats of 10 cwt. each per turn of from nine to ten hours. In working the double furnace it is found best to have one puddler only and two under-

hands, to avoid the division of responsibility that would arise in case of two puddlers working the same charge of iron.

SIX MONTHS' EXPERIENCE.

"Mr. W. Fisher, manager of Mr. Bennett's works, said, in answer to inquiries, that the puddling-machines had now been at work constantly during the day for the last six months at the Wombridge Iron-Works, and continued to work as well now as they did when first started; and there had been no occasion to repair any of the working parts since then, as the machines had been found very simple and strong. A man went round twice a day, and put a little oil on morning and evening; and they could be worked night and day when desired. At first there had been a little difficulty in introducing the machine; but now the men felt its advantage, and were anxious to have it employed on night-work also.

"The six months' experience of the working of the machine had shown that 5 cwt. of iron had been puddled by it in the time that a man would take to puddle 4 cwt.; and it was also found that the machine made a great improvement in the quality of the iron. This was accounted for by the fact that, while in hand-puddling there was the liability of under-hands to neglect their work, the machine went steadily on, working the tool constantly to and fro in the furnace without any intermission, and kept the iron well stirred during the whole time that the work was required to be put into it. The consequence was, that very seldom was a bit of raw iron seen from the puddling-furnaces worked by the machine; and the puddled bars were very seldom found to break off short in the rolling, unless the iron was too hot. In the heavy operation of puddling, it was impossible for any puddler to stand up to his work as the machine did, since the machine never tired, but kept steadily on without rest, and at a quicker rate of working than in hand-puddling. By using the machine to do the heavy part of the work, it was only required for the puddler occasionally to disengage the tool and draw the iron from the sides of the furnace into the centre, leaving the machine during the rest of the time to perform its work alone. When the iron was ready for balling up, the puddler came fresh to the work; and, from the men being relieved of the severest part of the labor, the furnaces worked by the machine turned out about 5 cwt. at each heat, and six heats during the day, with the same quantity of fuel as was used for the ordinary heats of only 4 cwt. in hand-puddling, with six heats per day. The average result of a day's work with the machine was about 28¾ cwt. of puddled iron from 30 cwt. of pig iron, as compared with about 22¼ cwt. of puddled iron from 24 cwt. of pig iron by hand-puddling. The improvements effected by the machine were, therefore, that it produced a better quality of iron, with a decreased consumption of fuel, and turned out more iron in the same time.

"The machine did not interfere with the wages of the under-hands, as they had to be employed the same as without the machine; whilst the puddler's wages were increased by his being enabled to turn out more iron in the same time."

We have witnessed and heard of several attempts to puddle iron by machinery, but none of the inventions with which we are familiar were successfully applied. The plan described in the foregoing quotation is undoubtedly practical and economical, and may be applied at all our rolling-mills with much benefit to proprietors and puddlers. There are, however, several other modes, which we will briefly describe.

IMPROVEMENTS IN PUDDLING.

A few years ago, the pig metal was always refined in the finery-furnace by the pneumatic process before use in the puddling-furnace. It has been found practical and more

economical, however, to deoxidize the metal at one process by "boiling" it in the puddling operation. This simply consists in the rapid ebullition of the gases produced by the more highly carbonized and, consequently, more fluid cast iron. The "boiling" process is more tedious and laborious than common puddling of refined metal, on account of the stirring necessary to burn out the larger amount of carbon in the pig metal.

Mr. Hall, of the Bloomfield Iron-Works, Tipton, England, first introduced the boiling process about thirty years ago.

Mr. James Nasmyth patented an improved process of puddling in 1854, which consists in the introduction of a small quantity of steam at a low pressure into the molten metal on the hearth of the furnace as soon as melted. The steam has both a mechanical and chemical action on the iron: being introduced at the bottom of the melted metal, the steam is instantly rarefied and diffused upwards, violently agitating the iron and causing the exposure of fresh surfaces to the oxygen passing through the furnace and the action of the steam.

The mode of applying the steam is by means of a small pipe, bent at the end, which enters the furnace for the purpose of passing down through the melted metal. This pipe is held horizontal by the puddler, and is swung on a ball-joint, which connects with a perpendicular pipe leading from the boilers. The workman can thus pass the horizontal steam-pipe over the entire hearth of the furnace. So rapid is the operation of steam, thus applied in decarbonizing the metal, that in the course of eight or ten minutes the mass begins to thicken, and the operation is then finished by the "rabble" of the puddler. The time saved by this simple process is considerable, and that during the hottest and most laborious part of the process. It is possible this mode of puddling may be superior to the machinery formerly described, and in connection with the gas puddling-furnace, which has been in use in Silesia, Germany, for twenty-four years with great success, the operations of decarbonizing pig metal in the puddling-furnace would be much simplified and economized.

The Silesian gas-furnace is much the same as the common reverberatory furnace, except that it is much larger, and that the fireplace is occupied by a gas-generator on the Siemens principle, which gives an intense heat and saves 33 per cent. of the fuel, while the puddling process is shortened and simplified.

In these furnaces the decarbonization is effected by the pneumatic process, the air being blown into the metal from each side of the furnace, on the same principle first applied in the Bessemer converter,—the charges being about 40 cwt. instead of 4 and 5 as used in hand-puddling. The make is improved, while the saving of metal, fuel, time, and labor is very great.

THE MANUFACTURE OF STEEL.

Steel is produced from iron, direct from the ores, by extracting a portion of the carbon from cast iron, or by adding carbon to malleable or bar iron. It is simply a compound of carbon and iron, as cast iron is; but cast iron contains from one to five per cent. of carbon, while steel contains only from a half to one per cent. of carbon. The best steel known to the cutlers of England and the sword-makers of Damascus is produced by the wootz manufacturers of India, whose operations have been conducted since the days of Alexander, or perhaps before the birth of Brahma. (?)

Steel can be made in the Catalan forge in small quantities, by using less ore and more charcoal, and simply raising the tuyer to prevent the blast from burning the carbon from the loup; but the steel so produced is very variable: sometimes a bloom of excellent steel may be produced, but more frequently it may contain too much carbon,

and be simple "pot-metal" or cast iron; or too little carbon, and, consequently, only wrought or malleable iron.

Steel has been produced as a carburet by simply decarbonizing cast iron in various ways for a long time. The process of refining pig metal formerly in general use, to prepare it for the puddling-furnace by blowing air into the liquid metal in the "finery-furnace," partially effects the decarbonization of pig metal and forms steel if continued. But the mechanical arrangement of the finery-furnace, and the action of the air blowing from the surface downwards, instead of from the bottom upwards, does not admit of economical or uniform results, since the iron becomes oxidized before the whole is sufficiently decarbonized to form steel.

A similar process, however, has been long in operation at the celebrated steel and iron works, called Konigshütte (king's forge), in Upper Silesia, Germany, where "natural steel," or a carburet, is made direct from the cast iron by means of a furnace on the principle of the old refining furnace; but the blast is supplied from below, and the pig metal, when melted, falls down *through the blast* to the bottom of the hearth in the shape of steel,—a process which may be made equally available with that now so celebrated under the name of the Bessemer process; and, as before stated, the same use is made of air for the decarbonization of cast iron in the puddling process, except that it is blown into the melted liquid in the latter, while the metal falls through the blast in the former.

Cast iron may be thoroughly deoxidized and refined by falling, while in a molten condition, through a strong blast of air and steam, the steam being produced by jets of water, or by the falling of the metal into water. As shown in the Nasmyth invention, described in a former page, steam is more effectual than air in deoxidizing cast iron.

CONVERSION OF BAR IRON TO STEEL.

As before stated, we first deoxidize and then carbonize iron, to convert it from the ore to the pig; we then decarbonize it by oxidization, to form bar iron; and lastly, we carbonize it again without the aid of oxygen, to form the steel of cementation. This is truly a roundabout way to accomplish that which should and can be done in the first process by the proper mechanical arrangement. This, however, has not yet been done in a successful and economical manner within our experience. Nor do we think it can be done—except for the production of superior grades of steel—in competition with the blast-furnace and the new application of air as a decarbonizer, since no mechanical arrangement can supersede the blast-furnace on the score of economy, provided the improvements of modern science and experience are applied as they arise.

STEEL OF CEMENTATION.

Steel of cementation, or that made from superior bars or good soft iron, by the addition of the proper quantity of carbon, is the most uniform and best for all the requirements of the arts that has yet been produced, or is likely to be produced for some time to come, by any other process. It has already been superseded, however, by Bessemer steel for most common uses, in which fine steel is not a necessity.

The best steel can only be made from the best iron, whether by one process or another; but, in the process of cementation, superior charcoal iron must be used exclusively in order to produce good steel; yet the best cast steel for tools and cutlery cannot be made even from superior charcoal bar unless produced from peculiar ores or mixed with the carburet of manganese.

The steel-manufacturers of England formerly imported all their bar iron from Sweden or Russia, but they subsequently found the iron of Ulverston, England, and

of Madras, India, to be equal to the best Swedish Danemora iron, which sold freely at £36 per ton when other brands of good Swedish charcoal iron sold for £15 the ton.

The black magnetic oxide of iron generally forms the best bar iron for cementation, but only peculiar kinds of this ore produce naturally the rare qualities of the Danemora iron. We find this peculiar ore in several localities in the United States, but always in the vicinity of limestone and always accompanied with a small percentage of manganese.

But in 1839, Mr. Josiah M. Heath, of England, obtained a patent for the use of manganese in the production of steel. It was found that by the introduction of one per cent. or less of carburet of manganese into the melting-pot along with the broken bars of blister steel, a cast steel was obtained, after fusion, of a quality much superior to that manufactured from common charcoal iron without the manganese.

In 1843, 25,000 tons of steel were converted in England; and of that quantity not more than 2500 tons were made from the imported bar. At one time, 70,000 tons of foreign bar iron were annually imported into England for the manufacture of steel and other purposes, for which domestic iron is now almost exclusively used; but Mr. Heath's invention enabled the steel-makers of England to produce good common steel even from ordinary coke iron. This invention has also made the Bessemer process a practical industry.

BLISTER STEEL.

Blister steel is a carburet of iron and the products of the cementing furnace. It is made by enclosing thin bars of wrought iron in an air-tight chest with powdered charcoal, subjected to a strong heat for eight or nine days, and then allowed to cool gradually for five or six more. About two tons of coal are used to the ton of blister steel produced, and about the same amount to fuse the blister steel in crucibles for the subsequent production of cast steel.

SHEER STEEL

is made by reheating the blister steel and drawing it out under a tilt-hammer. It loses part of its carbon by this process, and becomes softer and less crystalline in consequence. Sheer steel is used extensively for heavy springs and a great variety of common purposes in the arts. It is often used in the place of iron, since it is worked with equal facility by good smiths; while its strength, elasticity, and hardness under temper, where desired, renders it superior to iron for most purposes; but the increase of price, owing to the greater cost of production by the old processes, is much against its use generally. By the pneumatic process, however, steel having much the same quality may be made cheaper than iron.

CAST STEEL.

Cast steel is made by melting blister steel in fire-clay crucibles; but, since a portion of the carbon is dissipated in the fusion, the steel used for this purpose is more highly converted, or charged with more carbon in the cementing furnace, than that which is used for other purposes; but the amount of carbon taken up by the bars is never over one per cent., and seldom more than one-half per cent. The fuel used in the cast-steel furnaces of England is a dense, pure coke. When melted, the steel is poured into cast-iron moulds, of such sizes and shapes as may be desired; for ordinary uses, however, it is drawn under the hammer to bar steel.

CEMENTING FURNACES.

We do not propose to elaborate the method of producing steel by the old processes, but simply to give the chief points, in order to trace the modes and means of the manufacture, and to illustrate the new developments or inventions which arrive at the desired object directly, instead of indirectly, as by the old and roundabout process of decarbonization and recarbonization.

Fig. 182.

FRONT ELEVATION OF CEMENTING FURNACE.

Fig. 183.

SIDE ELEVATION OF CEMENTING FURNACE.

Fig. 184.

PLAN OF CEMENTING FURNACE.

DESCRIPTION.

The furnace of cementation, in which bar iron is converted into bar or blister steel, is represented in the foregoing figures. It is generally rectangular, and covered in by a groined or cloister arch; it contains two cementing-chests, *c*, *c*, made either of fire-stone or fire-brick; each chest, or cementing-trough, is about 2½ feet wide, 3 feet deep, and 12 feet long, and capable of cementing about six tons of bar iron at each heat. One of these chests is placed on each side of the fire-grate *A B*, which occupies the whole length of the furnace, and is from 13 to 14 feet long. The grate is 14 inches broad, and rests from 10 to 12 inches below the inferior plane or bottom-level of the chests; the height of the top of the arch above the chests is 5½ feet; the bottom of the

chests is nearly on a level with the ground, so that the bars do not need to be lifted high in charging the furnace.

The flame rises between the two chests, passes also below and around them through the horizontal and vertical flues *d*, and issues from the furnace by an opening, *H*, in the top of the vault, and by orifices, *t*, which communicate with the chimneys placed in the angles. The whole is placed within a large cone of bricks 25 or 30 feet high, and open at top; this cone increases the draft, makes it more regular, and carries off the smoke from the establishment.

The furnace has three doors: two, *T*, above the chests serve to admit and remove the bars; they are about 7 or 8 inches square; in each of them a piece of sheet iron is put, folded back on its edges, so as to save the wall in sliding the bars in and out of the chests.

A workman enters by the middle door *P* to arrange the bars; the trial bars are taken out from time to time through the apertures *s*, which are prepared for the purpose. The bars are laid in strata in the chests along with powdered charcoal made from young timber; these bars are three inches broad, and one-third of an inch thick; they must not be allowed to touch each other, but are separately imbedded in the charcoal; the uppermost layer is covered with a stratum of loamy matter from 4 to 5 inches thick.

The furnace must be heated gradually, not reaching its maximum temperature before 8 or 9 days, while the cooling lasts 5 or 6 days, and the whole operation 18 or 20 days. About 13 tons of coal are consumed in this period.

Many of our old steel-manufacturers make a great mystery about the secret ingredients—ashes, salt, &c.—which it was insisted must be used; but the best steel can be made without them as well as with them.

THE PNEUMATIC PROCESS.

Steel has been made by this process in Germany for a long period, while it has frequently been produced, both by accident and design, direct from the ore, by using more or less air in the operation of smelting, and more or less carbon (coal) in the conversion from ore to metal.

The most economical and practical application of oxygen for the decarbonization of cast iron is when the metal is fluid and direct from the blast-furnace. It can then be changed from a carburet to a soft iron by the process of oxidization, or by burning out the carbon by passing air through the fluid mass at high-pressure. This process is the same in effect as that which is produced in the puddling-furnace with so much more labor and cost. By that process, however, the pig metal is remelted (as it is frequently done in this) and the fluid mass is exposed to currents of flame and air passing over the surface by constant stirring, as formerly described. By the pneumatic process the air is blown with great force up through the molten metal, and, of course, accomplishes the same object more completely and with much greater economy.

The great difficulty has been in the mechanical appliances for effecting this purpose, and the experience required for the proper regulation of the blast, the time of deoxidization, and the improvement of the products by the requisite admixture of manganese, which is a necessity, for the production of good iron or steel.

A great many patents have been obtained in this country and Europe for the employment of air, steam, or gas in the deoxidization of cast iron. But we do not think any patent can cover a process which has been in use for ages. The mechanical means, however, of applying air to this purpose is open to competition, and always has been.

Henry Bessemer, of England, has been the most successful in this application, and deserves great credit for the practical manner in which he has accomplished the great

revolution in the manufacture and use of steel now going on, by which it may become less valuable than pure iron in regard to cost.

THE BESSEMER AND KELLY PATENTS.

The Bessemer patent for the United States was issued November 11, 1856; but on a trial of interference at our Patent Office, between Mr. Bessemer and William Kelly, of Eddyville, Kentucky, it was decided that *Mr. Kelly was the prior inventor*, and a patent was accordingly issued to him on the 20th of January, 1857.

Messrs. Winslow, Griswold & Holly, of Troy, New York, have obtained rights under Mr. Bessemer's patents for the United States; while the Wyandotte Steel Company of Detroit, Michigan, are operating under the Kelly patent. Between these parties, or rather between Mr. Bessemer and Mr. Kelly, an important law-suit is now pending, which will determine the priority and relative rights of the patentees, and perhaps fix the tithe or tribute which our steel-manufacturers must pay to England for the next generation.

It is now nearly ten years since we first saw Mr. Kelly's process tried, and it was then acknowledged practical and valuable; but the uncertainty of the manufacturing interests, and the slight encouragement given to our iron-industry, had, and has, so crushed its spirit of enterprise that but few of our iron-masters are willing to risk the expense of adopting new improvements, and none that cared to experiment with new inventions until they are forced to, as in the present instance, by the developments which invention and improvement have made in England.

We must either stop manufacturing steel or follow her example, and even then we cannot make steel in competition with her cheap labor, perfected improvements, and vast capital. Nothing will avail us but the protection afforded by *war* or *tariffs;* and no sensible man will court the former when the latter is so much more available, economical, and safe; but better the former than no protection to our industry.

The following letter from the Superintendent of the Wyandotte Company of Detroit, in relation to the manufacture of steel by the Kelly process, under rights granted by our Patent Office, after a full consideration of the priority of invention and relative claims of both Kelly and Bessemer, demonstrates practically that we are under no obligation to swell the vast revenues of Bessemer or pay tribute to England. The invention of Josiah M. Heath made the pneumatic process practical, and is really the only original and scientific part of the invention: the subsequent operations are merely mechanical, and there are many ways of accomplishing the object. But Bessemer pays no royalty to the heirs of the unfortunate Heath. The steel-manufacturers of Sheffield pirated his patent rights, and, though they made forty per cent. by the operation, they confederated for the purpose of defrauding the truly worthy inventor; and though England has saved many millions of pounds per annum by this original invention, she gave no reward to the man who rendered her so important and valuable a service, and has turned a deaf ear to the prayers of his family.

The researches and inventions of the scientific and able Mushet have also rendered great and important service to the pneumatic process now known in England as the "Bessemer," by his experiments to ascertain the proper alloys and combination of other metals with iron to give it the necessary quality for the production of steel. But Mr. Bessemer entirely ignores the claims of Mushet, and treats him as his predecessors treated Heath.

LETTER FROM ROBERT W. HUNT, OF THE WYANDOTTE STEEL-WORKS, DETROIT, MICHIGAN.

"WYANDOTTE, MICHIGAN, October 27, 1865.

"BURD PATTERSON, ESQ., POTTSVILLE, PA.

"Yesterday I received a letter from Mr. E. Yardley, in which he tells me you are much interested in the pneumatic process of making steel, and desires me to write you on the subject.

"I do this with much pleasure, and regret that I am compelled to be somewhat restrained and guarded in my statements.

"But an important suit is about taking place in regard to the different claims of patents on the process, and, as the parties by whom I am now employed are largely interested, I am not at liberty to write as freely as I should like. Kelly of America and Bessemer of England both have patents on the process in this country. The works at this place are carried on under Kelly's license; while the establishment of Messrs. Winslow, Griswold & Holly, at Troy, N. Y., is conducted under rights purchased from Bessemer. Which of the two has the best claim, time must decide.

"At these works we have one three-ton converter, which has been in use about a year; and we are now putting up another of like size.

"Since I have had charge of the works I have taken the metal direct from the blast-furnace, the converter being in the furnace-casting house. We run the iron into a large ladle, and, after weighing, hoist it with rotary engines and pour into the converter. The blast is then turned on, and kept at a pressure of about 15 pounds and a velocity of 3[illegible] cubic feet per minute. This blowing is continued until the carbon is burned out of the iron,—the length of time required being governed by the grade of iron treated, and ranging from 18 to 36 minutes, when a certain proportion of melted Franklinite pig from New Jersey is run into the converter and mixed with the decarbonized metal. This gives it the right proportion of carbon and manganese. This part of the process was invented by Mushet of England. After mixing the two metals, the contents of the converter are poured into a ladle, from which it is tipped into cast-iron ingot-moulds, from which the steel is removed when cold and is ready to be forged. By using the metal direct from the blast-furnace I save the fuel necessary for remelting the iron, and the waste incident in that process, while I am able to produce just as fine a quality of steel as is made at any other pneumatic works. I am sorry that the distance prevents my sending you some specimens of the steel: it is very peculiar in its character, and for very many purposes is very valuable. While it will weld firmly at a sand heat, it will take a good temper; it is very strong and stiff, while it will bend double when cold without showing a flaw. This fits it for all kinds of machinery where strength is required; and the fact that you obtain work without any welds renders it much safer and lasting. Its being so much stronger than iron will allow it to be rolled into boiler-plate that is much thinner than ordinary, and thus save in weight and fuel.

"The selling price in England is three times that of the same articles in iron: at least, this is so to the best of my information. Our works are not running just now, as I stopped on last Monday for the purpose of pushing ahead the addition and improvements, which I hope to have finished about the 1st of December.

"We have one of McKenzie's cupolas, in which we can melt iron for the process when the blast-furnace is not working well or when we wish to use a different grade of iron from that made here.

"This is an Americanism, and was first tried at these works in last June.

"The Troy manufacturers have since adopted the same plan.

"In England they use reverberatory furnaces which require about one pound of coal to two of iron. In the cupola one pound of coal will melt from eight to ten of iron.

"In my opinion, this process is certain to be largely introduced in this country, and while the dispute about the patents may retard its development, it will take place sooner or later. Very many of our irons are fitted for the process. The kind we use is Lake Superior charcoal. Any further information which I can give you will be most happily rendered. I remain

"Yours, truly,
"ROBERT W. HUNT."

THE PNEUMATIC PROCESS OF MANUFACTURING STEEL AND MALLEABLE IRON BY THE BESSEMER PATENT IN ENGLAND.

The following extracts from a paper recently read before the Mechanical Section of the British Association by Henry Bessemer, on his process of manufacturing steel, will illustrate the subject fully, and present to our readers a clear exposition of the mechanical means now employed and the mechanical difficulties through which they were obtained:—

"On the 13th of August, 1856, the author had the honor of reading a paper before the Mechanical Section of the British Association at Cheltenham. This paper, entitled 'The Manufacture of Malleable Iron and Steel without Fuel,' was the first account that appeared shadowing forth the important manufacture now generally known as the Bessemer process.

"It was only through the earnest solicitation of Mr. George Rennie, the then President of the Mechanical Section of this Association, that the invention was, at that early stage of its development, thus prominently brought forward; and when the author reflects on the amount of labor and the expenditure of time and money that were found to be still necessary before any commercial results from the working of the process were obtained, he has no doubt whatever but that, if the paper at Cheltenham had not then been read, the important system of manufacture to which it gave rise would to this hour have been wholly unknown.

"The diagram shows in section the original fixed converting-vessel, as patented and erected in London for experimental purposes in 1856. It will be observed that the tuyers were passed through the sides of the vessel in a horizontal direction; the result was that the blast of air entered only a short distance into the fluid mass, and much of it escaped upwards between the sides of the vessel and the metal. The effect of this was the rapid destruction of the brick lining, caused by the excessive temperature generated in the process and the solvent property of the resulting silcate of protoxide of iron, which sometimes destroyed a lining of half a brick in thickness during the blowing of two charges of metal for about twenty minutes each. Another difficulty arose from the impossibility of stopping the process without running out the metal; for if the blowing ceased for one instant the fluid metal would run into the tuyers and stop them up.

"A great inconvenience of the fixed vessel also arose from the danger and difficulty in tapping out the fluid malleable iron with a bar, after the manner of tapping an ordinary cupola-furnace; for the blast had to be continued during the whole time the charge was running out of the vessel, in order to prevent the remaining portions from entering the tuyers. A similar difficulty arose while running in the crude metal from the melting-furnace, since it was necessary to turn out the blast before any metal was run into the vessel: the first portions so run in were, in consequence, partially decarbonized before the whole of the crude metal had left the melting-furnace.

"These were among the more prominent difficulties that had to be remedied. It is,

however, satisfactory to know that even in this its infant state the process and apparatus were practically successful, in proof of which there is placed upon the table part of a malleable iron railway-bar made from pig iron, at Baxter House, by blowing air through it in the apparatus just described, the fluid malleable iron having been run into a 10-inch-square ingot-mould and the bloom so made rolled direct into the bar shown. The small malleable iron forged gun will serve as an example of the clearness and freedom from cracks or flaws in malleable iron so made and forged under the steam-hammer. It is one of the early productions of the process, and, like the malleable iron rail, was made wholly without any recarbonizing of the metal or the employment of spiegeleisen or manganese in any form whatever. Malleable iron so made from hematite pig iron is red short, like all other wrought iron made wholly from hematite; but that it is perfectly malleable and extremely tough when cold may be seen on examination of the iron rope exhibited, which consists of four rods of 1¼-inch round iron twisted cold into a close coil. These bars extended 13 inches in length in 4 feet, and were reduced nearly ⅛ inch in diameter in the operation of twisting, thus showing that malleable iron so made possesses an extraordinary degree of ductility.

"It may be remembered that an important part of the process, as described at Cheltenham in 1856, consisted in tapping the fluid crude iron from the blast-furnace, and allowing it to flow direct into the converting-vessel and be there blown to the extent only of decarbonizing it so far as to produce cast steel. This part of the original programme has been most successfully carried out in Sweden, where an extensive establishment for its manufacture has been erected by M. Goranson, of Gefle. The large steel circular saw plate exhibited is an example of the conversion of crude cast iron run direct from the blast-furnace into the converting-vessel and there blown for nine minutes, in which period it had been converted into cast steel of the desired quality, and was then poured into an ingot-mould without being recarbonized, and wholly without the employment of spiegeleisen or manganese in any form whatever.*

"With these few illustrations of the capabilities of the process, as originally described at Cheltenham, the author will proceed to show how the disadvantages of the old fixed converting-vessel were remedied and other improvements introduced. Many forms of converting-vessels were tried on the large scale before this desirable object was attained. In some of them the lining was too easily broken down by the violent motion of so heavy a fluid as iron; in some of the forms tried the angles allowed the metal to solidify in them, and so clog up the vessel; in others the mouth of the vessel being too small caused the metal to be thrown out by the force of the escaping blast. It was also found that if the mouth was too large the heat escaped, so as to cause part of the converted metal to solidify in the vessel; the relative height and diameter of the vessel was also found to produce important differences in the working of the process. Finally, and after many long and expensive trials, the form of vessel shown at B was adopted. (See figure 185.) This vessel is made in two parts, so as to admit easily of its being lined up with a pulverized silicious stone known as 'ganister,' which so resists the action of the heat and slags as to last for fully 100 consecutive charges of steel before it is worn out. Its form is that of the arch in every position which prevents the lining from falling down by its own weight. There are no angles in which the splashes of metal can solidify and accumulate. Its mouth directs the flame and sparks away from the workman, and from the moulds and other apparatus; while the throat of the vessel, and the position of the mouth, almost entirely prevents the throwing out of the metal. The vessel is mounted on trunnions supported on stout pedestals so that a semi-rotary motion may be communicated to it at pleasure. The tuyers are placed at the bottom of the vessel, so as to force the air vertically upward through the

* The iron employed must have been produced from manganiferous ores.—Author.

metal, as shown, without coming in contact with the sides of the vessel. When the crude metal is to be run into the vessel, it is turned on its axis nearly into the position shown at C, the mouth being a little higher up; a gutter will then conduct the crude cast iron from the melting-furnace into it. It is not necessary to turn on the blast until the whole of the metal is run in, because the tuyers occupy a position above the level of it. As soon as the air is admitted through the tuyers the vessel is turned into the position shown at B, when its decarbonization immediately commences. As soon as this is effected, as much molten pig iron made from spathose iron ore is added to it as will restore the quantity of carbon necessary to produce the desired quality of steel, which is then run into the casting-ladle in the manner shown, and from whence it is transferred to a series of iron moulds ranged in a semicircular pit, each mould being placed within the sweep of the casting-crane. The filling of these moulds is regulated by a cone-valve made of fire-clay and fitted in the bottom of the casting-ladle, so as to be opened or shut at pleasure by means of a handle on the outside of the ladle.

" 'It will be readily understood that in the fixed vessel first described, any giving way of a fire-clay tuyer would stop the process and cause much inconvenience; but with the movable vessel it is not so, for at any moment of time during the process the vessel may be turned on its axis and the tuyers raised above the level of the metal; the blast may then be turned off, the tuyer-box opened, and the faulty tuyer stopped up or removed, after which the process may be again resumed. The movement of the vessel on its axis, the rise and fall of the casting-crane, and the other cranes employed for removing ingots from the casting-pit, are all effected by a simple hydraulic apparatus, so that the whole process is under the perfect control of a single operator, placed far away from the heat and showers of splashes that accompany the process.

" 'Up to this period, the manufacture of cast steel by the old as well as the new process is still so far imperfect that steel of the highest quality cannot be made from inferior iron. In the old Sheffield process, the original quality of the Swedish charcoal iron employed governs the quality of the cast steel made: consequently, £36 per ton is freely given for the high-class Danemora iron, while other brands of Swedish charcoal iron may be bought for £15. In either case, these are expensive raw materials for the cast-steel maker.

" 'In 1839, the trade of Sheffield received an enormous impulse from the invention of Josiah Marshall Heath, who patented in this country the employment of metallic manganese, or, as he called it, "carburet of manganese." The addition of a small quantity of this metal, say from one-half to one per cent., rendered the inferior coke-made irons of this country available for making cast steel; it removed from these inferior qualities of iron their red-shortness, and conferred on the cast steel so made the property of welding and working soundly under the hammer.

" 'Manganese has now been used for many years in every cast-steel works in Europe. It matters not how cast steel is made, since manganese added to it necessarily produces the same beneficial changes. No one better appreciated this fact than the unfortunate Mr. Heath, as evidenced by his patent of 1839, in which he declares that his invention consists in "the use of carburet of manganese in any process whereby iron is converted into cast steel." Had Heath seen in his own day the Bessemer process in operation, he could not have said more: he well knew the effect produced by manganese on steel, and, therefore, claimed its employment in any process whereby iron is converted into cast steel.

" 'In the *Mining Journal* of September 24, 1853, just four years before the first of Mr. Mushet's series of patents, a letter was published on the subject of Heath's invention. The writer of that letter says, "I am a steel-maker, and deny that steel was ever made with the addition of carbon and manganese, or carburet of manganese, previously to Heath's invention, and I confidently assert that no cast-steel maker can now

carry on his business to profit without the aid of carburet of manganese." "There are," he says, "a hundred methods of improving steel with manganese, but they all involve the same principle. Put carbon and manganese into the steel-pot in any form you please and at any time you like, and, if the steel be thoroughly melted, the carburet of manganese melts also and is alloyed, and the improvement is unerringly effected, and by the use, in every instance, of carburet of manganese."

"At the suggestion of the author, a works for the production of manganese alloys was erected by Mr. Henderson, at Glasgow, who now makes a very pure alloy of iron and manganese, containing from twenty-five to thirty per cent. of the latter metal, and possessing many advantages over spiegeleisen, which it will doubtless replace. Two bright rods of 1¼ inch diameter will be found on the table: they were folded up cold under the hammer. This extremely tough metal is made by using Mr. Henderson's alloy in lieu of spiegeleisen, which is incapable of making steel of such a quality.

"'A Prussian gentleman, M. Preiger, has been also successful in manufacturing a new alloy, which he calls ferro manganese, consisting of sixty to eighty per cent. of metallic manganese. It is extremely useful in making malleable iron by the Bessemer process, in which spiegeleisen cannot be employed on account of the large proportion of carbon it contains.

"'It is supposed that there is not one spot on any railway in Europe where the amount of traffic equals that at the Chalk-farm bridge at Camden Town. At this spot there is a narrow throat in the line, from which converges the whole system of rails employed in the London termini of this great railway.* Here all passengers, goods, and coal-traffic have to pass; here, also, the making-up of trains and shunting of carriages is continually going on. At this particular spot two steel rails were fixed on May 2, 1862, on one side of the line, and two new iron rails were on the same day placed precisely opposite to them, so that no engine or carriage could pass over the iron rails without passing over the steel ones also. When the iron rails became too much worn to be any longer safe for the passage of trains, they were turned the other way upwards, and when the second side of the iron rails was worn as far as the safety of the traffic would allow, the worn-out rail was replaced by a new iron one,—the same process being repeated as often as was found necessary. Thus we find, at the date of the last report on March 1, 1865, that seven rails had been entirely worn out on both faces. Since then, another rail has been worn out up to July.

"'In conclusion, it may be remarked that cast steel is now being used as a substitute for iron to a great and rapidly increasing extent.

"'The jury reports of the International Exhibition of 1851 show that the entire production of steel of all kinds in Sheffield was, at that period, 35,000 tons annually, of which about 18,000 tons were cast steel,—equal to 346 tons per week; the few other small cast-steel works in the country would probably bring up this quantity to 400 tons per week as the entire production of cast steel in Great Britain. The jury report also states that an ingot of steel, called the "monster ingot," weighing 24 cwt., was exhibited by Messrs. Turton, and was supposed to be the largest mass of steel manufactured in England. Since that date a great change has been made; for the largest Bessemer apparatus at present erected at Sheffield, at the works of Messrs. John Brown & Co., is capable of producing with ease every four hours a mass of cast steel weighing 24 tons, being twenty times larger than the "monster ingot" of 1851.†

"'There are now seventeen extensive Bessemer steel-works in Great Britain. At the works of the Barrow Steel Company 1200 tons per week of finished steel can easily be turned out, and when their new converting-house, containing twelve more five-ton converters, is

* London & Northwestern Railway.

† An ingot or anvil of steel weighing 250 tons has since been cast in England of Bessemer steel.

completed, these magnificent works will be capable of producing weekly from 2000 to 2400 tons of cast steel. There are at present erected and in course of erection in England no less than sixty converting-vessels, each capable of producing from three to ten tons at a single charge. When in regular operation, these vessels are capable of producing fully 6000 tons of steel weekly, or equal to fifteen times the entire production of cast steel in Great Britain before the introduction of the Bessemer process. The average selling price of this steel is at least £20 per ton below the average price at which cast steel was sold at the period mentioned. With the present means of production, therefore, a saving of no less than £6,240,000 per annum may be effected in Great Britain alone, even in this infant state of the Bessemer steel manufacture.' "—*London Engineer*, September 15.

THE MACHINERY REQUIRED BY THE BESSEMER PROCESS.

The Bessemer process is exceedingly simple. The whole process rests upon the action which a strong current of air exerts upon the elements with which it meets when forced through a mass of melted pig iron. The stirring and combustion which it produces transform certain qualities of cast iron into a malleable metal that may be wrought like cast steel. The Bessemer process is, therefore, a method of refining. The operation is performed in a large egg-shaped vessel; the cast iron is poured in in a liquid condition, and then the air is forced beneath it at a high pressure. The metallic mass remains fluid while the air acts upon it. The resulting malleable product is obtained in certain cases by stopping the air while the process is yet incomplete, or, more generally, by prolonging its action until the iron is converted into a sort of burned or over-refined mass, and then transforming this product immediately into a malleable metal by means of the simple addition of a crystalline and steely iron. The process was at first carried on in a sort of fixed cupola-furnace, into which air was driven by tuyers passing through the bottom; but on account of the trouble caused by the tuyers clogging, another arrangement was substituted, where the vessel in which the process is executed is called the *converter*, and is a movable egg-shaped pot, with a short neck. It is made of plates of iron riveted together, and protected inside with a sheeting of refractory clay, 12 inches in thickness. At about the height of its centre of gravity this vessel is suspended upon two trunnions, to which are geared wheels that enable the apparatus to be turned by hand or by machinery on a horizontal axis. An air-box which occupies the lower part of this converter communicates with the interior by means of a number of small holes passing through the fire-brick bottom. The air passes from the blowing-engines through a hollow trunnion, thence into the bottom of the converter, and may be thrown in small jets into its interior, no matter in what position the vessel may be turned. The capacity of the converter is usually from five to six times the amount of the cast iron to be treated. The throat should be large enough to let out the gases when the process is in operation, and to enable the fluid metal to be poured in and out without danger of obstruction. During the operation of converting, the mouth of the converter passes under a hood of sheet iron, which carries the fumes to a chimney. When the operation is terminated, the converter is turned over, and all the metal it contains is poured into a ladle, at the bottom of which is a hole, out of which the fluid mass can be tapped. The metal has a tendency to cool rapidly, and must be poured into the moulds soon, and with care that it shall not touch the walls of the mould. In order to accomplish this, a hydraulic crane is used, of which the pivot is a piston playing in a cylinder, and at the end of a horizontal arm extending from this pivot is fixed the ladle; the moulds are placed in a circle around the pivot at such distance that a hole in the bottom of the ladle can be brought directly over the centre of each of them by revolving

the crane, while the height of the ladle above the mould may be fixed by raising or lowering its piston-pivot by hydraulic power.

The blowing-engines are of various patterns. The average pressure of the air

FIG. 185.

THE BESSEMER EGG-SHAPED CONVERTER IN BLAST.

DESCRIPTION.—We have not lettered this engraving. A reference to the following figures will be sufficient to explain it.

should be from 15 to 25 pounds to the square inch, and it should be thrown into the converter through thirty-five tuyers, each ½ inch in diameter.

It is, however, always best to have a considerable surplus of power in the blowing apparatus. When the cast iron is not taken directly from the blast-furnace in a liquid state, it is necessary to have a reverberatory or cupola-furnace for remelting it: this should be placed at such a height above the level of the converter that the liquid iron will flow readily from the former into the latter. It may be elevated in ladles, however, to the converter, as done at the Wyandotte Works, Michigan. The iron should be introduced into the converter as hot and fluid as possible.

THE METHOD OF OPERATING THE MACHINERY JUST DESCRIBED.

To produce Bessemer or Pneumatic Steel.

During the treatment of cast iron in the Bessemer apparatus, the operator concentrates his attention upon the following points:—the character of the flames and sparks that flow from the mouth of the converter; the character of the smoke that rises from the top of the chimney, which, by reason of the abundant sparks generated in the operation, cannot be studied below; the noise of the cast iron in the converter; the height of the air-gauge, which indicates the pressure necessary to force the air from the tuyers; and, finally, upon the duration of each of the phenomena of the process, and the total duration of the blowing.

Let us watch, for an example, the converting of a charge of three tons of red-hema-

tite charcoal iron through the process of conversion into steel. The air is blown at a pressure of 20 pounds to the square inch.

The converter is first heated white-hot before the metal is poured in, by filling it with coke, and blowing into it gently with the blast-engine. The coke is poured out, and the vessel returned to its erect position; the metal from a reverberatory furnace is then run by a trough into the converter, and the blast turned on. The blowing is continued twenty-two minutes, until over-refined iron is produced. The vessel is then turned to a horizontal position, the blast stopped, and an addition of 7½ per cent. of Franklinite or other spathose iron containing manganese, in a fused condition, is made: this is mixed thoroughly, and the mixture poured into the ladle above described, and thence into the moulds. In looking more closely into the process, we may divide the twenty-two minutes during which the blast is being driven into the fused metal into four periods.

First. Lasting seven to eight minutes, being the period of sparks, and until flames commence.

Second. Period of eight minutes, during which flames augment and the "dart-like" flame is formed.

Third. Period of two minutes, of detonations and eruptions.

Fourth. Period of four or five minutes, increase of amount and brilliancy of flame until the flame falls.

FIRST PERIOD.

Upon the air reaching the fused metal, large numbers of sparks are projected through the neck of the vessel and into the chimney by the violent blast. These are combustible particles, that burn brilliantly in the oxidizing currents. The chimney as yet produces no smoke. The noise formed in the converter is dry and crackling, and indicates that the metal raised by the blast falls back upon itself. The noise grows gradually into a regular and dull clapping. The iron, during this period, becomes more and more hot and liquid. The combustion, however, is accompanied by no visible flame.

During this period the combustion, which causes the metal to grow hotter and hotter, does not appear to produce any combustible gas. The current flowing from the converter appears to be still oxidizing, since the sparks continue to burn in the midst of the current. If the iron is poured now, it has the appearance of pig partly refined and having lost but little in weight. These facts lead us to believe that a part of the oxygen passes through the iron uncombined, and that the combustion is caused by the oxidation of a body more oxidizable than iron, without attacking sensibly as yet the carbon or the iron. The sparks are, indeed, as characteristic of the combustion of silicum and metallic manganese, as of iron.

We may, then, conclude that the heat at the beginning of the operation is furnished by the oxidation of a body more combustible than iron; that the carbon, if it burns at all, produces carbonic acid gas; and that the temperature of the mass is not high enough to absorb all the oxygen.

SECOND PERIOD.

The sparks diminish, and are masked and replaced by flame. At six or seven minutes a red, dull, short flame begins to show itself; at eight minutes it is more distinct, and begins to be yellowish and bright. At first only a few inches long, it gradually grows to be three feet in length. About the middle of the period, a dart-like flame shows itself at the throat of the converter, resembling the flame of a candle, and continues during the remainder of this and a part of the following period. The noise in the converter becomes drier and drier, and less perceptible, and is replaced by a sound like the formation of innumerable bubbles of gas. No smoke yet issues from the chimney. The back-pressure of the air diminishes.

During the second period, the presence of a flame like that of a candle proves that the combustion of carbon is followed by the production of carbonic oxide, and the oxygen is now entirely absorbed by the combustible matter in the fluid mass, since the jet of gas at the mouth of the converter burns only on the surface when it comes in contact with the air.

THIRD PERIOD.

The flames remain; strong detonations take place in the apparatus; they are accompanied by the projection of viscid portions of the interior mass, mixed with metallic grains, against the wall of the chimney. The flames appear more clear during several seconds after each explosion. These explosions do not seem to be essential to the process; and a skilful operator will at length succeed with most irons in working without them. The noise produced at this time is similar to that of a fluid mass in a state of violent ebullition. Much smoke now issues from the chimney. At this period the iron burns directly and its combustion is very lively. The oxide of iron is carried off as smoke, and the loss in weight is considerable.

The iron has now reached a period when it is somewhat viscid, having been refined till it has reached a condition of malleability. Bubbles are formed, and when they receive oxygen and carbonic oxide in proper proportions they become explosive.

FOURTH PERIOD.

A calm now succeeds. A long white flame extends from the mouth of the converter. Soon this flame experiences an entire change. It becomes torn on the edges, trembles, and suddenly falls, as though the blowing-engine had in a moment lost nine-tenths of its power. After this fall the flames are not bright, and much smoke issues from the converter. The opèration is now stopped. If it be continued, there will be a rapid formation of silicate by the fused lining of the converter combining with the oxidized metal, and ultimately an oily fluid silicate of iron will fill the converter.

Practice teaches how to seize the exact moment to stop, that the required degree of hardness may be produced. It is always a delicate point to determine the exact moment when the operation shall be discontinued.

When the flame falls, the converter has within it a very fluid metal holding much gas in solution, which, if allowed to cool, is not malleable, and resembles in its fracture what is known as "burned iron." The action of the blast is terminated by reversing the apparatus and shutting the air-valve.

During the fourth period, the continuance of the flame proves that the combustible gas is produced in abundance; but the cessation of detonations shows that the iron has acquired a temperature sufficiently high to absorb all the oxygen thrown into it. The combustion of the last portions of carbon (probably the graphite) appears to take place indirectly by the decomposition of the oxide of iron, free or combined. The iron has become almost exclusively the combustible substance. Its affinity for oxygen increases with its temperature, and the action of the mass is in favor of its combustion, in preference to the sulphur, the phosphorus, and other bodies that have escaped burning at former periods. The refining, therefore, can be carried no further. The flame produced at this period is white and brilliant: it falls generally when the last particles of carbon have disappeared.

The final product is always very liquid. The slags formed towards the last of the operation run easily, are glassy-black without, and yellowish-green within.

Seven and one-third per cent. of fused spiegeleisen, from Siegen, or other manganiferous iron, melted in a special compartment of the reverberatory furnace, is then introduced by means of a small crane and ladle. The addition of this metal always pro-

duces a tumultuous action, which is more or less violent in proportion to the amount of air that has been driven in, and varying with the different irons treated.

After allowing the metal to mix thoroughly, it may be poured into the ladle on the crane without turning up the converter; but if it is desired to make the mixture still more complete, it may be done by bringing the converter again to a vertical position and blowing air into it for a few seconds. The metal is then poured into the distributing ladle. During this last blast the flame passes from red to yellow, and the same phenomena are seen to occur in rapid succession as have been described above.

From the distributing ladle the diffused metal must be run, before it cools, into the ingot-mould.

FIG. 186.

CONVERTER AND LADLE.—POURING THE LIQUID STEEL.

DESCRIPTION.—*a*, the converter; *b*, blast-apertures; *c*, ladle; *d*, hydraulic ram; *e*, ingot-moulds.

COMPARATIVE ECONOMY OF THE BESSEMER OR PNEUMATIC PROCESS.

By this method of making steel, a great saving of fuel is secured. The product is in a cast condition; and hence, in comparing it with the cementing process, we will consider the expenditure in producing ingots by each plan.

It requires for 1 unit of steel $2\frac{1}{2}$ units of coal to produce from the pig the cemented or blister steel; and for 1 unit of steel $2\frac{1}{2}$ units of coke to fuse this cement steel, and from therefrom ingot cast steel. Supposing the coke to represent 60 per cent. of the original coal, we have, upon addition, 7 units of coal necessary to produce 1 unit of common cast steel.

In the pneumatic process, using iron directly from the blast-furnace, no fuel is absolutely required, except what may be necessary to heat the interior of the converter: the power to drive the blowing-machine may be water. To heat the converter requires $\frac{1}{8}$ of a unit of fuel to a unit of steel.

If, however, we suppose it necessary to remelt the cast iron in a reverberatory furnace, it requires 60 per cent. of the weight of iron in coal to perform this office.* Hence we may conclude that 1 part of fuel in the Bessemer process will produce as much steel as 6 or 7 parts in the old method by cementation, and that hence there is a saving of $\frac{5}{6}$ to $\frac{6}{7}$ in the amount of fuel necessary.

* In the cupola-furnace, which is an American improvement, one ton of good anthracite will melt eight tons of cast iron; but when the fluid metal from the blast-furnace is run into the converter, these are not required.

The labor, the keeping up of the machinery, the consumption of fire-clay, are items small in amount when summed up and compared with the same in other processes. At Woolwich, Bessemer estimated that steel could be sold at $34 per ton when pig iron was costing $18 per ton. Of course, this proportion will vary with different countries. The chief economy is in the fuel, which is an important fact to be considered by the inhabitants of those regions where fuel is dear or of inferior quality; and the process may lead to some most important revolutions in the iron-industry of the world, by transferring the business to regions hitherto unfrequented by iron-manufacturers.

The discovery of this method of making steel was peculiarly opportune. No process ever was invented at a moment more favorable for its development. The metallurgic era in which we live demands vast quantities of steel in large masses. We have left behind us the day when quality alone was considered: quantity is now our uppermost idea. We are clamorous for processes to economize time. This furnishes the most sanguine with all he can desire. In less than an hour the liquid cast iron can be converted and drawn into merchantable steel; the process of cementation requires, to produce the same results, the tedious lapse of several weeks.

The usual method supplies ingots of from 40 to 80 pounds weight, which only by great efforts may be increased to several thousand pounds. With this plan we may cast with ease an ingot of 10,000 pounds; and by using several converters at the same time, masses may be obtained of a size the limits of which we cannot assign. Finally, nearly all the movements of the apparatus may be accomplished by steam; the labor of the puddler has no counterpart; muscle is everywhere supplanted by skill; man ceases to be the beast of burden, and, assuming his truer sphere, observes, judges, and directs.

IMPROVEMENTS IN THE MECHANICAL MEANS EMPLOYED.

The great difficulty, since the invention of Heath in 1839, has been in the application of mechanical means to effect the decarbonization of cast metal to form wrought iron, and the *re*carbonization to form steel. The means employed by Mr. Bessemer are the

Fig. 187.

BESSEMER'S IMPROVED GLOBULAR CONVERTER.

Description.—*a*, *a*, blast-pipes; *c*, inside of the converter; *d*, wheel used for reversing the converter or pouring the metal; *b*, ram used for elevating the blast-pipe out of the converter.

best which have been applied, but perhaps not the best that may be applied. There is always room for invention; and American inventors proverbially lead all others in mechanics. Give them the inducement and an idea, tell them what you want and

what you will pay, and if the reward is worthy of the object you will be sure to realize your wishes.

There is no wider field for invention, no greater reward offered to industry or ingenuity, than may be found in the full development of our resources of coal and iron, and the realization of their wealth by science and art, provided, however, that our domestic industry is protected and encouraged.

This globular converter is a decided improvement on the egg-shaped converter, both in the economy and effect of the application. The blast-pipe is simple, and can be lowered into and elevated out of the converter at pleasure, and can be repaired without hindrance to the operations, which cannot be done in the egg converter, since the converter must be cooled and remain idle while the tuyers, &c. are being repaired. The converter being spherical has more surface, and the metal will expose a greater surface and a less depth to the blast, and, consequently, requiring a smaller amount of pressure to penetrate the liquid mass.

But improvement will not stop at this. While the works erected by Mr. Bessemer in England exhibit great mechanical skill, substantiality, and enormous cost, they do not manifest the ingenuity which generally characterizes American inventions. There is an evident want of simplicity and economy in the Bessemer arrangements, which do not admit of application to old establishments without great cost and alteration.

The great first principle involved—that of blowing air into molten cast metal—cannot be secured to any inventor, since it has been in use for ages; but the mechanical means of applying the blast, and the general arrangement of the apparatus, are as open to invention and improvement to-day as they were one hundred years ago.

RÉSUMÉ.

Having briefly traced the modes and means by which iron and steel have been elaborated from the ore since the early development of the art of smelting to the present time, we may now sum up the facts, and thus be enabled to comprehend more clearly the present status of these great and important branches of our manufacturing industry.

1. Rich and pure iron ores will always produce good iron in the blast-furnace if pure fuel is used; and charcoal iron is always superior to that produced by mineral fuel, because charcoal contains less impurity than the best mineral coal.

2. All ores must go through a process of torrefaction and oxidization before they can be successfully smelted or reduced to iron; and the smaller the particles of ore, and the more intimately these can be brought in contact with carbon under a strong heat, the sooner and more thoroughly will this process be completed.

3. The principle applied in the blast-furnace for the reduction of ores to cast iron is the simplest and most economical that has yet been made use of or suggested, and it seems impossible that any better mode can be applied. The only desirable improvements we can now appreciate are the preparation of the ores for easy and full deoxidization, the increase of temperature in the blast by utilizing the furnace-gases, and the use of the caloric given off by burning coal without its impurities.

4. The decarbonization of cast iron while in a fluid condition direct from the blast-furnace by the use of air blown through the liquid mass, in place of the tedious, costly, and imperfect process of puddling, and the recarbonization and purification of the iron by the proper admixture of carbon and manganese.

The modes of effecting these improvements are plainly set forth by the requirements, while the means are simply those now in daily use. We only need combination and skilful mechanism to develop our iron-industry in a state of perfection to our present

comprehension; the production of superior wrought iron and steel from good ordinary ores with mineral fuel at a cost but little exceeding cast iron.

The limits of this work will not admit a full illustration of these improvements. We have far exceeded the space originally allotted us on the subject of iron, and can only add, in conclusion, an earnest hope that our brief notice may not only aid in directing our readers to the accomplishment of the desired economy in the development of our mineral resources, but encourage such legislation as will lead to the realization of their immense wealth at an early day.

The statistics of iron will be found in the Appendix.

PART VII.

CHAPTER XXX.

PETROLEUM.—ITS GEOLOGY, DISTRIBUTION, ETC.

Petroleum—Hydro-Carbons—Volcanic Vapors, Gases, and Oil—Pitch Lake of Trinidad—Cuba—Other Localities—Petroleum of the Coal-Fields—Geology of Petroleum—Petroleum Rocks of the Great Basin—Oil-Bearing Rocks of the Alleghany Coal-Field—Formation of Rock-Oil in the Great Basin—Natural Processes—Anthracite Coal—Geological Position of Rock-Oil—Petroleum of the Alleghany Coal-Field—Favorable Conditions for the Existence of Rock-Oil—Practical Observations—Geological Horizons of Petroleum—Flowing Wells—Action of the Gas—Gas Wells—Distribution of Rock-Oil—Petroleum of Canada—Burmah—Persia—China—Distillation of Coal-Oil—Coal and Coal-Oil.

PETROLEUM is derived from the Latin word *petra*, a rock, and *oleum*, oil, or rock-oil, and, as such, has been known and used to a limited extent for ages. It is also known as naphtha, which, however, is the lightest variety of hydro-carbons when in the condition of oil. But the constituents of petroleum also exist in the condition of gas, chiefly as a carburetted hydrogen. Light carburetted, or bicarburet of hydrogen, is its most volatile character. In this condition it consists of one equivalent of carbon and two of hydrogen, mixed, perhaps, with a small proportion of other gases. Hydrogen is the lightest gas known, and in proportion to its volume in connection with carbon will be the density of the hydro-carbon. Heavy carburet, or proto-carburet of hydrogen, consists of one equivalent of each. This gas condensed produces naphtha, which is the most volatile of rock-oils; yet by long exposure to atmospheric influences it turns to bitumen or asphaltum by the evaporation of the hydrogen and the absorption of a small quantity of oxygen.

Petroleum is essentially a compound of carbon and hydrogen. The lighter kinds, in their native condition, consist of nearly equal parts of carbon and hydrogen; but by weight, from 85 to 90 of carbon, and from 10 to 15 of hydrogen.

Water consists of one volume of oxygen and two of hydrogen, but by weight, 88.9 of oxygen to 11.1 of hydrogen. Under a high degree of heat, hydrogen unites with carbon, but under intense cold it unites with oxygen. In the first it forms gas or oil, and in the last, water or ice.

Hydrogen has no affinity for carbon under a high degree of cold: in fact, they seem to exist in combination naturally in a state of gas, which can be maintained only by heat or confinement. If liberated, they part readily in the temperature of summer. Naphtha or petroleum cannot be confined in ordinary barrels, since the light hydrogen will find a way out, even through the pores of the wood, and when exposed on the surface of water or within the influence of the air it soon becomes bitumen or very heavy oil.

Thus, we find the hydro-carbons in many forms, ranging from the lightest gas to a heavy, solid substance. First, we see it in the state of gas, which is its normal condition; then as naphtha, or gas condensed by cold and the loss of hydrogen. Petroleum

is only a heavier oil, containing more carbon than naphtha and less hydrogen, as we find fully exemplified in our oil-wells.

The upper oil, or that nearest the surface, is always the heaviest, thickest, and most valuable, simply because it has lost a great part of its hydrogen and become thick and heavy in consequence. The *second* oils, or those found beneath the third sandrock, in Venango county, Pennsylvania, are very light when found at the depth of 500 to 700 feet, but only moderately so at the depth of 200 to 300. The same oils, in the Great Kanawha Valley, at a depth of 1500 feet, exist as gas or light naphtha.

But, in whatever form it may exist in Nature, when exposed to atmospheric influences it becomes heavy and thick, and finally a solid, by the evaporation of the hydrogen and the consequent condensation of the carbon. The carbon can only be maintained in a state of vapor or gas by great heat. In a mean or low temperature it forms oil in combination with either hydrogen or oxygen; (?) but in the temperature of the atmosphere, in summer or winter, it parts with both and becomes solid, as asphaltum, bitumen, cannel coal, bituminous coal, anthracite, and diamond. These can again be resolved by heat to vapor, and in connection with oxygen they form carbonic oxide or carbonic acid, and with hydrogen, carburetted hydrogen gas or hydro-carbon oils. If subject to heat in connection with the atmosphere, they will produce the first; but if exposed to subterranean heat,—either the internal and volcanic heat of the earth, or that caused by great depth and pressure,—the latter will be the result.

The vapors escaping from smouldering volcanoes, if passed up through water, form oil by condensation, as many instances bear witness.

VOLCANIC VAPORS, GASES, AND OILS.

At Zante, one of the Ionian Islands, is an oil-spring still flowing, which was mentioned by Herodotus more than two thousand years ago.

In the north of Italy petroleum has for nearly two centuries furnished the gas for lighting the streets of Genoa and Parma; while at Baku, on the Caspian Sea, are numerous springs of naphtha issuing from the crevices of volcanic rocks. Pits or wells are dug from ten to twenty feet deep, and in these the oil is gathered as it issues from the rocks.

In Judea, in the volcanic region of the Dead Sea, oil rises through the water and forms bitumen on its surface by the evaporation of the hydrogen; and at the base of Mount Vesuvius the vapors arising from the smouldering volcano through the waters of the sea, which washes its base, are found on the surface as naphtha, or rock-oil; while submarine volcanoes always produce oil on the surface of the waters through which their vapors ascend.

THE PITCH LAKE OF TRINIDAD.

This celebrated lake of petroleum, pitch, or bitumen is found on the highest land in the island of Trinidad, one of the West Indian Islands. It is supposed to be three miles in circumference, and entirely covered with a crust of bitumen or pitch, on which men or animals may walk with safety in cold or cool weather; but in hot weather it liquefies and becomes soft and unsafe. The thickness of the mass has not been ascertained, but it is known to be of great depth. This lake of petroleum is in a volcanic region; and not only in the lake, but in the surrounding rocks, exist fissures containing liquid petroleum, which arises through the waters of the lake, and, of course, the fissures in the rocks below and around it, and by evaporation or the loss of its hydrogen forms pitch or bitumen on the surface. The resulting bitumen when cold is hard and brittle, resembling anthracite coal when broken, by its conchoidal fracture, but contains more earthy impurities, from the dust and floating particles carried by the winds on the surface of the lake.

Near this lake exists a submarine volcano, which occasionally boils up and produces large quantities of petroleum, which floats on the surface of the water; while on the other side of the island a second volcano produces oil in still greater abundance, which by evaporation leaves masses of black and brilliant bitumen on the surface and along the shore.

ROCK-OIL AND BITUMEN OF CUBA.

The so-called chapapote, or bitumen, of Cuba, which is mined as coal and often designated as such, occurs in the fissures of the rocks, and generally at right angles to the strata, demonstrating its origin from subterranean vapors, forming oil on condensation, and subsequently bitumen by the escape of its hydrogen. Flowing springs of petroleum still exist in the vicinity, emanating from the fissures in the rocks, which extend through the stratified surface-rocks to the metamorphic and plutonic below. The rocks of the whole island seem impregnated with bitumen, and petroleum springs are found in numberless places; while the bay of Havana affords bitumen enough along the shores to supply a sufficiency in the place of tar for the purpose of caulking and "paying" the ships in the harbor.

OTHER LOCALITIES.

Bitumen and petroleum like those of Trinidad and Cuba are also found near the city of Maracaybo in Venezuela, at Murinda in New Granada, and in numerous volcanic localities in Mexico and California; but the consistency and purity of the resulting bitumen depend on the character and quantity of earthy impurities with which it is associated.

A description was given to the War Department in 1844 of a small lake of petroleum which exists in Texas. This lake is about one hundred miles from Houston. It is reported to be filled with bitumen which, during winter, is hard. In the summer, petroleum boils up continually, which by the evaporation of its hydrogen becomes bitumen, and hard, black, and brilliant.

All the localities here described are in volcanic regions, and the oils originate in fissures leading from smouldering subterranean fires, or from volcanoes direct, and, consequently, cannot result from organic remains or fossils of animals or plants, since none ever existed in the plutonic rocks. Those hydro-carbons must, therefore, result from the vapors of smouldering subterranean fires, volcanic heat, or the chemical action of latent heat under pressure on the carbonated rocks.

It is a well-known fact that all rocks contain more or less carbon; and we do not speculate in assuming the original constituents of the earth, when in its liquid condition, to hold a large amount of carbon, as the chief cause of its caloric. As the carbon escaped in vapor, the liquid and fiery ball began to form its rocky crust,—at first slowly and by the condensation of its surface, in which but little carbon and no bitumen could exist, since carbon, hydrogen, and oxygen were held as vapor by the heat, and could not condense in the forms in which it now exists in the carbonated or bituminous rocks, slates, and shales.

But when the crust of the earth grew thick, and the igneous rocks were covered by the metamorphic, the radiating heat had diminished so that the vapors of carbon began to return to the earth in the shape of carbonic acid, in limestones, &c. During later periods, the vapor of carbon which issued, and still issue, from the internal heat of the earth did not escape entirely in vapor, but became condensed while arising through the thickening crust, in connection with hydrogen, and formed hydro-carbon oil, which, in localities having the requisite conditions, formed coal; in others, bituminous shale, asphaltum, bitumen, &c. But in localities not prepared to hold it in basin-shape, the

oil was carried away by tides or waves, became too minutely distributed and mixed with earthy impurities to produce distinct masses or beds of pure bitumen or coal.

After the formation of coal in our great basins, the production of those subterranean gases diminished, and those produced became condensed before reaching the surface in the form of oil; while the continual contraction of the rocky crust of the earth by condensation on cooling closed its pores and fissures, and sealed much of the oil and gas in its deep cavities. In the coal-fields the strata grew continually, until the basins in which they formed were filled to their brims, mud and clays extended in immense horizons from edge to edge, while stratum upon stratum of sand and shale and coal added thickness to thickness, and formed a sealed and impenetrable cover to the gases still arising from the lower and still heated rocks. These gases accumulated, and, by their great tension, forced themselves into and between the strata wherever a lodgement could be found, and escaped to the surface in the form of gas or oil through every fissure or crack presenting the means of escape.

When we examine the solidity of our rocky strata, even in the most disturbed and dislocated localities, it seems strange that gas or oil should find a way to the surface; but when we consider the tension in which these subterranean gases must exist, we cease to wonder. The constant generation of gas, which may exert several thousand pounds' pressure to the square inch, under a surface of many thousands of square miles, would lift the whole bodily, unless vents were found through which it could escape. When large fissures exist, through which petroleum and gas escape to the surface, they invariably become filled with solid bitumen by the evaporation of its lighter and more volatile portions. Thus, in West Virginia we find a vein of bitumen or asphaltum existing in a fissure which extends across the strata of the sedimentary rocks in which it exists; while in Cuba and many other parts of the world, as before stated, we find the same resulting bitumen in fissures, lakes, &c.

It may be possible that both gas and oil are still forming to a limited extent, but it is scarcely probable. The carbon and bitumen of the rocks, which resulted from a former excess of carbon, may now yield it again to the chemical action going on in the earth under pressure and contact with water. (?) Water could not penetrate deep into the earth when the rocks were in a heated or warm condition, but would evaporate in steam. On this part of our subject we do not propose to theorize, since there is no natural process on which to form a thesis with any certainty, or which can be demonstrated by existing facts.

GEOLOGY OF PETROLEUM.

We have offered abundant proof of the production of petroleum by volcanic heat, and given evidence and substantial reasons why the hydro-carbons are produced by the vapors of carbon in and from rocks containing no trace of organic or fossil remains.

It is a well-known fact that charcoal will impart its carbon under heat to iron, and that it escapes in vapor, under a strong heat, without the aid of oxygen; but that it will combine with oxygen when free, or with hydrogen when in contact, and in a state of vapor. It is, consequently, as natural and logical to assume that the vapors escaping from the smouldering internal fires of the earth or from volcanoes should unite with the hydrogen of water, since the latter must exist in the condition of steam in the vicinity of volcanic heat or where acted on by hot vapors, though it would naturally condense on passing upwards through the colder water near the surface; but the vapor of carbon having united with hydrogen will only part with it again by slow evaporation in a condensing or comparatively cold atmosphere.

We do not propose in this connection to examine every known locality of petroleum, or account for its existence in all known formations, but will confine ourselves chiefly

to the geology of the Appalachian formations and their deposits of petroleum. In the examination of this great basin the whole subject will be presented, and the conditions in which petroleum exists generally will come under discussion.

PETROLEUM ROCKS OF THE GREAT BASIN.

We have given a representation of both the ancient and modern formation of the eastern part of the Great Basin in figure 4, Chapter III. In this figure, the dark lines underlying the white rocks which support the coal are designed as the Devonian oil-bearing rocks or strata: they are thicker in the engraving than the proper proportion, but exhibit correctly their position, from the steep eastern basins under the anthracite coal-fields to the wide and shallow basins of Western Pennsylvania and Ohio. This picture, however, is an imaginative one, and only given to illustrate the natural processes by which the Palæozoic formations of the Great Basin grew into present shape and form.

Figure 117, in Chapter XVII., illustrating the Great Basin in its actual or present condition, and relative depreciation of strata westward, conveys a general idea of the subordinate or intermediate basins, and the succession and comparative thickness of the succeeding formations overlying the granite and composing the metamorphic and Palæozoic. This representation, however, exhibits the formations west of the Alleghanies to the Rocky Mountains; while figure 4 is designed to illustrate the succession from the granite of the East and the Chesapeake Bay to the Ohio. The Devonian oil-formation is shown beneath the sandstones and limestones supporting the coal; but the relative thickness of this formation is proportionally less in thickness in its westward spread than represented in figure 117.

Figure 2, in Chapter II., representing the Palæozoic column in the vicinity of the anthracite coal-fields, gives the thickness of the Devonian rocks from the Ponent, or old red sandstone, to the Meridian or Oriskany sandstone inclusive, at 15,000 feet. These rocks include the Catskill, Chemung, Portage, Genesee, Hamilton, Marcellus, Upper Helderberg, Schoharie, and Oriskany, of New York.

In Venango county, and Western Pennsylvania generally, the Ponent entirely disappears, and all the formations thin rapidly in that direction, and the probable thickness of the Devonian oil-rocks in that locality may not be more than from 1000 to 1500

FIG. 136.

OIL-BEARING ROCKS.

DESCRIPTION.—a, a, coal measures; b, millstone grit; c, upper or heavy oils; d, limestone, increasing in thickness towards the southwest, or centre of the Great Basin; c, c, c, sandrocks of Northwestern Pennsylvania; e, lower or light oils; g, anticlinals, which are found at intervals, running from northeast to southwest.

feet in thickness. In Illinois, and the Great Central coal-field generally, the thickness of the formations making up the Devonian is not over 300 feet, as shown by figure 128. In Missouri, within the same coal-field, it is about the same, as shown in figure 131. But the distance from the coal or surface to these oil-bearing rocks is much greater on

the Great Kanawha, in West Virginia, in Illinois, and Missouri, than in Venango. There the Devonian rocks come to the surface in the deep valleys, and the millstone grit of the coal formation caps the highest hills from 400 to 600 feet above the level of the streams. But on the Great Kanawha the millstone grit is under the bed of the river, and the geological horizon is, consequently, from 500 to 700 feet higher on the Kanawha at Charleston than on Oil Creek at Sheafer; and, while the sandstones thin in a southwestern direction, the limestones increase. In Venango, the limestone strata are thin plates of only a few feet in thickness, while below the Kanawha, in West Virginia, they range from 500 to 1000 feet in thickness, and occur between the upper or heavy oils and the middle oils, as illustrated in figure 188.

The foregoing figure illustrates the gradual thinning or decrease of the sandrocks, and the thickening or increase of the limestones, towards the centre of the Great Basin. Perhaps in no part of the Appalachian formations are the conditions necessary for the existence of oil so favorable as in Northwestern Pennsylvania, as we may here briefly describe before tracing the formations farther west; but we may state, as preliminary, the fact of the intervention of the Carboniferous or Mountain limestone, as illustrated in figures 128 and 131, between the upper and lower oils in all the Western States. This limestone is only 3 feet thick on the northeastern escarpment of the Alleghanies, about 200 under the Ohio at Wheeling, and over 1000 at the mouth of the Great Kanawha, and through the West.

OIL-REGIONS OF NORTHWESTERN PENNSYLVANIA.

The oil wells of Venango and vicinity are more productive than those of any other region yet developed, and the geological formation of this portion of the Alleghany coal-field would lead us to expect this result naturally.

First. The several oil-bearing strata are here brought into a comparatively small thickness by the thinning of the sandstones from the east to the west, and the absence of the heavy limestones which farther to the southwest overlie the Devonian oil-formation and greatly increase the depth at which they exist. As before stated, the upper oils are always the thickest, heaviest, and most valuable, because the more volatile parts escape when near the surface; the middle oils, or those which exist at a reasonable depth from the surface,—say from three to six hundred feet deep,—are the most abundant, because at this depth it exists as naphtha, and contains the greater portion of its hydrogen; but at a greater depth—say from 1000 to 1500 feet—the hydro-carbons exist principally in a state of gas, which to the present time has not been utilized. There may be exceptions to this depth in the West, since there we may expect heavy oils at a greater depth, on account of the lower temperature which always existed there.

Second. The oil-formations of Northwestern Pennsylvania lie along the northeastern outcrops of the Great Basin. Here the Devonian rocks approach the surface, bringing their oils within a practical depth below the influence of the atmosphere which thickens, and above the chemical action which holds the hydro-carbons in a state of gas.

Third. The even, undisturbed, and horizontal position of the strata in this region is extremely favorable to the existence or preservation of the oil in its fountains, which are thus sealed for use. The fine-grained texture of the sandstones, and their solid, unbroken spread, the close and tenacious strata of shales and slates, and the intercalating clays, prevent the escape of the gas or oil in exhausting quantities.

Fourth. The middle position of this region, between the extreme heat of the East and the low temperature of the West, was favorable to the original formation of oil: and this we think one of the great secrets of the abundance of oils along the central portions of the Great Alleghany coal-field.

We might assign other reasons, but the foregoing are sufficient. It will be necessary,

however, to explain more fully the last item, since this may account for the formation of oil, as well as its abundant existence in certain localities, and limited existence in others, within the Great Basin.

FORMATION OF THE APPALACHIAN OILS.

We have shown that the vapors of carbon produce oil direct from volcanic sources and the internal heat of smouldering subterranean fires. This seems too palpable a fact to need more explanation or illustration; and, since we can see and comprehend in this a natural and probable process, it is neither profitable nor necessary to seek other theories which offer no means of demonstration. Most writers on this subject ascribe the production of rock-oil to the organic remains which lie entombed so thickly in the Devonian formations. But we think there is little probability that all the millions of mollusca entombed beneath the rocky crust of Venango would produce the flow of a single great well like the Noble, the Sherman, or the Phillips: a "shoal of whales" would not produce such astonishing results. That the fat of these ancient inhabitants of the inland sea should accumulate in certain localities to produce our present reservoirs of oil is likewise not only improbable, but impossible. Liberated oil or gas always rises to the surface of water, and this ancient life could only exist in water, and only find their tomb beneath it, from whence their oil must ascend to the surface almost immediately, as the results of pressure and heat. It, therefore, could never again sink, or exist beneath the water in the shape of oil or gas, but only as coal or bituminous shale.

But there are other reasons, more conclusive, against the theory of the formation of oil from the organic remains entombed in the Devonian oil-bearing rocks. Every circumstance of the formation and existence of the strata filling the Great Basin demonstrates the fact of heat and volcanic violence as the general accompaniment of every great sandstone formation, and the palæontological breaks following these extensive formations likewise demonstrate the fact by the destruction of life during these periods. It is evident, therefore, that the ancient life was entombed during periods of great heat, and that its oils were expelled both by the temperature of the rocks and the water, and by the pressure of the rocky strata in which they were buried. The oil thus expelled would then rise to the surface of the water, and no process could afterwards seal this oil in the earth except in the form of coal or bitumen. Never, since the periods of time during which those great changes occurred, have the conditions been so favorable for the production of the oils from the organic remains or fossils of the Devonian rocks, and these fossils, if now subject to test, produce less oil than the rocks above them. We, therefore, cannot accept this theory as a probable or a possible one to account for the existence and formation of petroleum.

As stated and demonstrated, the existence and production of petroleum were in far greater abundance during the Carboniferous era than before or since: before, because the heat was too intense to admit of its condensation from vapor and gas; and since, because the temperature of the earth has been too low to produce the vapor or gas in abundance. The Carboniferous era witnessed the waters of the Great Basin covered with the bituminous results of petroleum, like the pitch lakes of Trinidad and Texas, and the beds of coal were precipitated by their own weight or the rapid accumulations of the rocky strata over them during the seasons of volcanic action, which were then intermittent.

The lower coal-beds in the proto-Carboniferous strata are limited, and even the first beds in the true coal measures and on the conglomerate, or millstone grit, are comparatively small, impure, and thin; but the succeeding beds are in some localities immense, as witness the great Mammoth bed of the anthracite regions and the middle beds of the Alleghany coal-field generally. But we again witness a depreciation in the upper

measures, and the last beds formed are thin, few, and valueless, because the temperature at this period was much lower, and the production of petroleum, consequently, much less abundant.

It is natural, however, to assume that the gases which produced the petroleum on the surface of the water should accumulate still at a greater depth after the completion of the Palæozoic column, since the heat receded from the surface, and the rocks at a great depth still maintained a comparatively high temperature. The gases thus accumulating were then sealed in the rocks beneath the coal by the closing of the pores of the earth by contraction and condensation.

That this process continued for a considerable period after the formation of our great coal-beds is manifest, from the fact that the Devonian rocks are impregnated with bitumen, which could not have resulted prior to the formation of coal, because the gas up to the period was too light to be condensed by the heated rocks: indeed, they rather tended to keep the gas in its volatile condition, and could not have taken up the bitumen of the condensed gas, forming oil, until a late period.

This fact is further demonstrated by the absence of bitumen in the Eastern formations and its abundant presence in the formations of the West. In the East, the temperature was much higher during the formation of the massive sandstones which here predominate, than it was in the West, where the limestones accumulated during the same periods. *Here* we find but little bitumen in the rocky strata, but *there* we find bitumen general in all the strata, and some of the rocks saturated with it, as the Corniferous limestone, for instance. Here we find the bitumen resulting from the superabundant vapors and the subsequent petroleum in massive and solid beds of anthracite; there we find it in a few thin beds of highly bituminous coal, proving that the temperature was lower in the West than in the East, and that, while the petroleum produced was originally more limited, it combined with the rocky strata, in which it condensed, instead of arising to the surface of the water to form large beds of coal.

VOLCANIC INFLUENCES.

We are aware that we advance a new doctrine in ascribing the formation of our great sandstones, carbon-oils, and coal-beds to internal heat and volcanic causes; but these natural processes are made so manifest, and all the coincidents agree so harmoniously, that we present them as *facts* rather than theories, and we believe our candid, unprejudiced reader will rejoice to find the creation of our earth in its present form, the accumulation of the vast Palæozoic strata of the Great Basin, and the formation of our immense coal-beds the work of a limited period compared with the many millions of years required by the present theories of creation,—theories, too, let us remark, originally advanced by the infidel writers, who triumphantly flourished them, to prove the BIBLE a myth.

In order to bring the subject permanently and clearly to the mind, we will here again briefly restate the arguments and facts presented in the early pages of this work in describing the formation of the Appalachian strata.

NATURAL PROCESSES.

Volcanic ranges generally exist in long lines along the weaker axes of the earth's crust, and where these volcanic vents exist, there those weak lines naturally remain; where the condensed vapors and lava of the earth first find vent, there it will continue to vent; because, while other portions of the crust are growing thicker and stronger in consequence, these points remain much the same. They always exist in granite forma-

tions, though frequently overlapped by the metamorphic, and sometimes nearly covered by the Palæozoic.

The great ranges of volcanoes, extinct or otherwise, which now extend over the face of the earth, existed in the early days of creation as soon, or almost as soon, as its granite crust was formed; for, as soon as condensation and consequent contraction took place, the confined vapors and molten matter began to exist in a state of tension, and forced their way through the accumulating crust, when that tension became too great, in long and immense lines of volcanic vents.

Mountains also assumed lines rather than cones, following almost invariably the volcanic lines, and resulting from lateral contractions, which naturally formed its folds on the weakest points, as represented in figure 6, Chapter III. The great volcanic lines formed the barriers of great basins or seas, since they occupied the highest points and the water the lowest. But up to the period of the metamorphic or crystalline stratified rocks the earth was surrounded by vapors, and the oxygen and hydrogen only combined to form water when the temperature admitted of its existence in that condition, instead of in the state of steam or vapor.

The metamorphic rocks were formed by the lava vented from the volcanic ranges into the water surrounding them, which, being hot, crystallized the lava deposited as sediment. On being thrown into the water in a molten condition, the lava was shivered to atoms, and thrown up into the air with steam and vapor, to be carried by winds and tides and waves, as ashes and dust, to remote localities.

This process must be rapid. A long line of active volcanoes, reaching perhaps from Nova Scotia to Cuba, vented, almost without intermission, immense streams of lava into the deep waters of ancient seas forming the Great Basin. Such a process would not require millions of years to form our metamorphic strata: perhaps a *few years* might suffice.

That such a line of volcanic vents did exist along our Eastern granite range, there is ample evidence to prove; and that such was the process by which not only our metamorphic but our great Palæozoic sandrocks were formed, admits of palpable demonstration.

We find the basins deepest along this line of vents, proving the depression to have been greatest here; we find the strata at very high angles of inclination, sometimes inverted, in evidence of the lateral contraction, which naturally produced its apparent results along the weakest lines of the crust; we see a vast difference in the thickness of the strata here than elsewhere, and we notice that it gradually grows thin and fine-grained as it recedes from the place of production. It is plain that the immense plates of sandstones, shales, slates, iron ores, and coal could not be produced by rivers, tides, waves, or other causes, from the wear and tear of higher lands surrounding the Great Basin, since each of those immense horizons is the product of one cause, one operation, one period, and is formed of the same material throughout. Had they been produced by other causes than volcanic action, they would have presented a *breccia*,—an *olla podrida* of divers material.

But the great horizons formed by the Potsdam sandstone, the Medina or Levant, the Vespertine, and other rocks are coextensive with the great Palæozoic basin between the Blue Ridge and the Rocky Mountains. They are invariably thin towards the West—mere knife-edges; but along their Eastern outcrops they are of immense thickness. And not only do the sandstones present this evidence of their source, but all the accompanying strata present, by their decreasing thickness and coarseness, evidence of volcanic production from the Eastern line of vents.

The vapors of carbon arising from this great region of heat must have been in greater volumes than anywhere else within the Great Basin. But the intensity of the heat prevented their condensation, or the formation of oil, until a comparatively late era, along

this range; when the temperature permitted it, we find the results in our immense beds of anthracite coal; but we do not find the rocks impregnated, because its condensation did not take place while ascending through the rocky strata, but through the waters of our deep coal-basins, on the surface of which it floated and gave up its more volatile hydrogen, leaving a resulting bitumen almost, and in some cases entirely, devoid of hydrogen, oxygen, or other gases, and a *pure carbon* in the shape of anthracite coal. It would be almost impossible, during a time like this, or, in fact, at any time, for a deposit of this kind to form on the surface of the water without the addition of earthy impurities from floating dust, ashes, and smoke to some extent.

ANTHRACITE COAL.

We have before stated that vegetable matter may, and in all probability did, aid in producing coal, but, we believe, only to a very limited extent. That vegetation grew luxuriantly during the coal era there can be no doubt; and that it grew in the deep basins in which coal was formed is likewise evident; but that the woody fibre of vegetation formed coal is not only doubtful, but contrary to all evidence, and at variance with the coincidents of coal formations. It may have formed the impurities—bone and slate—of the coal, but never its pure carbon. The woody tissue supposed to be detected by microscopic examination cannot be determined in pure coal; and that found, or supposed to be found, in the ashes of coal is no criterion, since if the woody fibre of plants formed any part of a coal-seam it must have been the earthy parts thereof.

We have rarely seen a fossil plant in the midst of a coal-bed or within the coal; but whenever found in this condition it is *not coal*, but *slate* or *bone*.

A specimen may be seen in the office of Messrs. Connor & Patterson, of Pottsville, Pennsylvania, which demonstrates this fact. Coal-plants of the Carboniferous era, in a fossil condition, are invariably silicious or calcareous, and partake of the lithological character of the formation in which they are found.

But we do not intend to deny that the magnificent flora of the Carboniferous era aided in the production of coal. We believe it did, and have before so stated. That the rich and resinous calamites, coniferæ, &c., which were fed by a superabundance of carbon and carbonic acid, should yield oil on pressure, there cannot be a doubt; and that they were subject to immense pressure between the rocky strata in which they now exist is evident not only by their flattened forms, but the fact that the superincumbent strata would exert such an influence and expel the resinous oils which they contained. This oil would mingle with the hydro-carbons, and, by evaporation, form bitumen; and this, enclosed in the strata of the coal-measures and subject to pressure, would produce coal.

We gave the best vegetable theory available in the early pages of this book, but stated then that we did not consider any of those theories tenable. We are now positive of the fact, and state positively that all pure coal-beds are formed from petroleum or oil, resulting from the vapors of carbon directly or indirectly, as above set forth.

That a gradual depression of our great coal-basins did take place is not only evident from existing facts, but the natural processes of condensation and contraction. It is not, however, necessary that such must have been a condition to account for the formation of our coal-beds and the accumulation of the accompanying measures, since these beds and the rocky strata in which they exist would form as regularly and uniformly in basins of a constant depth as in those of varying depths.

The fact, in this case, that coal-beds are invariably thin at a great depth, or more so than they are at moderate depth, is explained by the simple fact that they must have existed originally in a soft and plastic condition, and were, consequently, moved by the great pressure of water and sediment resting on them from the centre of deep basins

towards their edges,—a fact demonstrated in all deep basins, except that of Richmond, Virginia, where the irregular form of the intermediate basins prevented such a movement.

ABSENCE OF PETROLEUM IN THE EAST.

We do not find petroleum in the deep basins of the East, or the presence of bitumen in their Devonian rocks: first, because the high state of temperature tended rather to volatilize than condense the gases; and second, because their high angle and frequent undulation, caused by contraction, gave the gases a full vent. We cannot, therefore, expect ever to find petroleum east of the Alleghanies, and not always to the west of them, except beneath the wide plateaux, where the gases are condensed and sealed as oil.

If petroleum existed east of the Alleghany escarpment, it must have been in the deep Devonian basins, which lie 20,000 feet below the anthracite coal formations; and, consequently, if it existed now at such a great depth it would not be available.

We may not expect to find rock-oil in any large amount beneath the semi-anthracite basins or the semi-bituminous basins on the eastern edge of the Alleghany field. Nor can we expect to find much of it in the detached basins, like those of Sullivan, Tioga, and Lycoming counties, where the formation is cut down by steam below the level of the upper or heavy oil. If the second reservoirs exist beneath the red shale in such localities, the depth to the oil-bearing stratum would still be very great, and the hydrocarbons would exist in a state of gas instead of rock-oil.

GEOLOGICAL POSITIONS OF ROCK-OIL.

Figure 189 illustrates the several horizons of petroleum and the hydro-carbons generally. We have made the gas and oil reservoirs or strata much larger in proportion than they exist in nature; but we wish to convey the idea rather than the actual status,—which, we must state, can only be conjectural. A stratum of oil, even if large enough to supply for years our great flowing wells, would appear as a faint line only if drawn to a scale on our section; and the thin leaders or jets of gas ascending through the earth, if made in proportion to their actual sizes, would scarcely be seen. In this figure, *a* represents the general level of the Great Kanawha near Charleston; *b*, the region of heavy petroleum; *c*, the general level of Oil Creek; *d*, the region of the second oil; and *e*, the lower oil, or gas.

These horizons of oil seem to be general, but they are not invariably of the consistence here specified. For instance, the lower oil formation existing in the Corniferous limestone of the upper Silurian rocks may be 2000 feet deep on Oil Creek and 2700 feet beneath the Great Kanawha, and its hydro-carbon exist only as gas. But in certain portions of Kentucky this rock appears to come near the surface, and in Canada it crops out. In the oil-regions of Chatham, in the vicinity of Lake St. Clair, Canada, it is very productive. The wells there are from 300 to 500 feet deep, and the oil produced is a fair petroleum, of about the same density as that produced in Oil Creek, Pennsylvania, at the same depth. The second oils, in the shallow wells of Northwestern Pennsylvania, are only from 33° to 38° Beaumé's hydrometer, and in the deep wells from 46° to 50°; but under the Great Kanawha it exists principally as gas or the lightest naphtha. It thus appears that the density of the oil depends more on its proximity to the surface than on the geological horizon in which it exists.

As before observed, the volatile parts escape when exposed, or when the means of escape are offered, and condensation takes place in consequence. On long exposure, nothing but the solids is left, and whether exposed to a moderate heat or cold, the same thing happens; but under a low temperature bitumen is left, composed of carbon,

FIG. 189.

Pittsburg seam..................

Barren measures...............

Heavy oils in the coal measures.
Level of the Great Kanawh

Millstone grit....................

Upper oils of the Great and Little Kanawha and Ohio, known as heavy oil.

Level of Oil Creek...........

Gas-leaders and crevices.....

Salt strata and gas reservoirs, intended to represent the Great Kanawha region, but is also applicable to Venango and Northwestern Pennsylvania generally.

Second oils, existing in the Great Kanawha Valley as gas or naphtha, and in the deep wells of Northwestern Pennsylvania as light petroleum.

Lower oils, existing as petroleum in Canada, as naphtha in Kentucky, and as gas generally in West Virginia and Northwestern Pennsylvania. It is in the vicinity of the Corniferous limestone.

GEOLOGICAL POSITIONS OF ROCK-OIL.

hydrogen, and oxygen, corresponding to the bituminous coals of the West; under a moderately high temperature, a comparatively pure carbon is left, corresponding to the anthracite coals of Pennsylvania; but if the heat be excessive, even the carbon becomes or remains volatile, and no residue remains. This is demonstrated by the fact that heat will change the hardest anthracite to vapor,—a chemical operation which we may see effected every day by the combustion of coal.

LOCALITIES AND CONDITIONS OF OIL-FORMATIONS.

The same arguments hold good in relation to the existence of rock-oil as to coal, viz.: certain conditions of position, lithological structure, and topographical feature are required for the one as well as the other, since oil produces coal. We have seen that both petroleum and coal are produced in and from granitic formations, as well as from and in the Palæozoic,—in volcanic regions and in the stratified fossiliferous. But in the former the coal and oil are both limited: first, because condensation could only take place when the temperature of volcanic regions was reduced to the proper standard, or below the boiling-point and second, because neither the lithological structure nor the physical features of such regions admits of their retention or formation in extensive fields. We find petroleum existing abundantly in Cuba, which is a volcanic region of late activity, and we find coal in the crater of an extinct volcano, as the Richmond coal-field, in Virginia, which was of much older activity, and yet much more recent than the true Carboniferous formations.

In volcanic regions the temperature is naturally high, and it remained high even when it became low

in the centre of the Great Basin. The volcanoes of the East continued to vent their lava until the highest sandrocks in our coal measures were formed; and the fact of a continual increase of bitumen from the East towards the West proves that the temperature decreased in the same proportion in that direction. We find that the hydro-carbons were produced in greater abundance in the East than the West; but we find, too, that nearly all their volatile matter was expelled on the Lehigh, less on the Susquehanna, and still less on the waters of the Juniata: yet our coal-beds are of an immense thickness, individually or as an aggregate, in the East, and very limited in the West. Though more than half the volume of the oil was expelled in the East by the higher temperature, we still have a greater residue left than in the West, where the low temperature admitted of the solidification of the oil with half its volatile matter remaining. This is proved by the fact that anthracite coal in the Lehigh basins contains scarce a trace of hydrogen or other volatile matter than water; while the cannel coal of Kanawha and some of the rich bituminous coals of the West contain more than half their weight in volatile substances. Between these extremes of temperature exists every grade of coal, from the pure carbon of the hard anthracites to the bitumen of the most volatile cannel.

The causes of this are evident: first, a gradual removal from the volcanic regions of heat; and second, a gradual elevation from the internal heat of the earth, by the constant accumulation of the Palæozoic strata in the waters of the Great Basin. The same causes, of course, affect the present existence of oil, as they affected the production of coal. We see that the quantity of coal decreases in a westward direction, as all the stratified rocks decrease: consequently, the volumes of gas arising and the oil and bitumen resulting must have been in relative proportion. That is, the oil was limited then, as the coal is limited now, and the same may be said of the proportions to-day. Much of the bitumen, however, of the West is taken up by the rocks through which it arose to the surface, because the condensation took place at a lower point there than farther east in the Alleghany coal-field. But it is against all reason and the laws of chemistry to expect the bitumen of the rocks to produce oil. It requires heat to effect this; and that which did not produce it during early ages cannot produce it now. If the rocks now holding bitumen obtained their bitumen from the ascending oils or organic remains, as they must have done, because they were cool enough to condense it, can it be possible for them to yield it again in oil or gas if they continue to grow colder? It is evident that heat alone can produce oil or gas from the bituminous rocks; and since they certainly are not accumulating heat, even if they do not grow colder, they can never give up their bitumen as oil in nature. The Corniferous limestone will yield its bitumen in the sun, as may be seen at the celebrated "oil-stone" church in Chicago; but if left in the earth the oil would never be disturbed. This is a plain statement of fact; there is no theory about it, and, therefore, it upsets entirely the doctrine which accounts for the production of rock-oil from the organic remains of the fossiliferous Devonian strata.

We find by practical experience, as we argue from cause and effect, that no available rock-oil exists in the Eastern basins or the Devonian rocks east of the Alleghany escarpment, for reasons before stated; and we find, by the same processes, that but little available petroleum exists in the great regions west of the Ohio and the Mississippi, but less and less in a westward direction: first, because it was never so abundant in the West as in the East; and second, because the petroleum of the Devonian rocks—its most abundant region, generally—lies too deep below the surface to exist in the state of oil, if it exists at all. The mountain limestone is over one thousand feet thick in the Great Central coal-field; and, therefore, through a great portion of this field the Devonian oil-formation must be from 1000 to 2000 feet below the surface, at which depth the hydro-carbon exists principally in a state of gas.

The Great Central coal-field of Indiana, Kentucky, Illinois, Missouri, Iowa, and

other Western States, contains but a limited thickness of coal in a few thin seams on their northern and western border, proving that the amount of bitumen which existed on the waters along the borders of this great inland basin was extremely limited: consequently, we cannot expect to find petroleum to any great extent in the rocks beneath those portions of that field.

In Eastern Kentucky a different result may be expected. There the basins are deep and the coal-seams are numerous and highly bituminous, while the shale is also highly charged with bitumen. The mountain or Carboniferous limestone is not in its usual Western thickness, and the Devonian rocks come nearer to the coal measures. It is also nearer to the volcanic regions of heat, since the coal of Eastern Kentucky is as near the Blue Ridge as that of Northwestern Pennsylvania: hence we may expect a great portion of the Central coal-field in Kentucky, and perhaps in Southern Illinois and Indiana, to be oil-producing territory. In Western Kentucky the same results may be obtained.

PETROLEUM OF THE ALLEGHANY COAL-FIELD.

The great region of rock-oil is within the wide and undulating basins of this coal-field between the anticlinal of Laurel Hill and its outcrops in Ohio. It may also exist between the anticlinals of Laurel Hill and Negro Mountain in available quantities; but the elevation of the strata on these anticlinals does not produce a favorable condition, but the reverse.

Within the wide plateau which extends from Chestnut Ridge beyond the Ohio, and along the vast horizon of nearly level strata that stretch through the northwestern counties of this great coal-field, we find, as we might reasonably expect to find, an abundant region of oil. But though these portions of the field present more available conditions to the existence and production of oil, it is by no means confined to them. The strike of this formation is parallel with the coal-field and its accompanying strata, passing the Little Kanawha east and west of Burning Spring, the Great Kanawha above and below Charleston, the Big Sandy from its mouth to the Russel Fork, and from thence through Western Kentucky into Tennessee and Alabama. But we do not think any great quantity of oil will ever be found in the two latter States, because most of the Devonian or oil-producing rocks are above water-level, with their outcrops exposed; and in such a condition oil cannot exist. In the basins of Alabama, however, where the coal measures descend below the surface, oil should be found, and we have no doubt it will be found.

FAVORABLE CONDITIONS FOR THE EXISTENCE OF OIL IN AVAILABLE QUANTITIES.

There are certain conditions, as before stated, necessary to the existence of oil in available quantities and position. These are, briefly—simply considering the lithological and topographical features: first, uniformity of stratification; second, horizontal position; third, the absence of fissures, dikes, and crevices for the abundant escape of gas; fourth, closeness of texture and stratification in rocks, slates, shales, and clays; fifth, a medium depth: if too high, all or most of the petroleum will have evaporated; if too low, it will be difficult of access and only exist in a state of gas.

It has been found, and will always be found, that the most available petroleum exists at a depth of from 300 to 700 feet. If found higher, it is always in limited quantities and heavy; but if lower, it will be very light and gaseous.

It has been proven by a thousand oil-wells in Northwestern Pennsylvania that the distance from the millstone grit of the coal measures to the most abundant reservoirs

of petroleum is about one thousand feet. But there most of the productive wells have been started from four to six hundred feet below the coal measures. The same oil-formation exists beneath the coal-field to the south, but the coal comes down gradually to the level of the rivers and streams, and eventually passes under them in that direction. In such localities the depth of the oil will be from 1000 to 1500 feet; and, as before observed, at such depth the hydro-carbons exist in a state of gas. Continuing still south and west, the Carboniferous limestone increases rapidly in thickness, and divides the Devonian oil-formation from the coal measures. It is only three feet thick on the Alleghany escarpment, two hundred feet beneath the Ohio at Wheeling, and one thousand feet thick under the Great Kanawha. This increase of the mountain limestone places the region of the second oils in a southwestern direction beyond available depth, under present developments; but the time will come when both the means to reach those deep hydro-carbons and the means of utilizing their gases will be obtained.

The most available regions of petroleum in the great Alleghany coal-field will, therefore, be found, where the Devonian rocks are most accessible, within the wide and undulating plateau before mentioned; and perhaps it will be found in greater quantities along their eastern margins than on their western outcrops.

Where the anticlinals sink beneath the coal measures, and yet preserve to some extent their shape, it is manifest the oil-rocks will be nearer to the surface than in the basins, and, consequently, bring the oil within available distance. This feature is represented at *g*, in figure 188, and may be studied at what is erroneously called the "Great Upheaval" on the Little Kanawha.

But within certain portions of the coal-field, where the base of the barren measures forms the bed-rocks of the streams, the upper petroleum may be found in available quantities in wells of 600 or 700 feet deep, or just beneath the millstone grit. At lower geological levels—say from the lower Freeport seam E, or even from the great seam of Karthaus, B—the upper oils may be, and, in fact, are, found productive at less depth. The upper oil-rocks produce most of the petroleum on the Little Kanawha and in all the region between that point and the second oil-rocks of Northwestern Pennsylvania, all the oil of Ohio, the Great Kanawha, and Western Kentucky, simply because the second oil-formation exists at a great depth, and the auger has not yet penetrated it, except on the Great Kanawha, where the salt-makers have reached its gaseous fountains, and there its flow has been terrific, as gas.

PRACTICAL OBSERVATIONS.

It may be difficult to ascertain from the foregoing description where the most available points to bore for oil may exist. We will, therefore, briefly state a few practical observations.

The most productive region of petroleum, as before stated, exists within the broad plateau extending from the western anticlinals of the Alleghany coal-field to and perhaps beyond the Ohio River. We can scarcely state a given line, but may say that little petroleum can be expected within the eastern basins: all or most of it exists on the western declivities.

To select good boring territory within this great region, several important geological observations must be made. First, it must be remembered that the most abundant fountains of oil exist at from about 400 to 700 feet from the surface; second, that more oil may justly be expected from the second than the first formation of oil-rocks; third, that the first formation exists at from 100 to 400 feet below the coal measures; fourth, that the second formation is about 1000 feet below these measures where the Carboniferous limestones do not exist, and 1500 feet where it does exist; fifth, the lithological

structure must be uniform, and nearly horizontal; sixth, there must be no steep dips or dikes or abundant gas-fissures in the vicinity.

By observing these lithological and topographical features, oil may be found in almost any part of the wide region described, provided wells are not put down where the formation comes too near the surface, nor where it is too deep; for in the first place little or no oil will be struck, and in the second nothing but gas will be found.

GEOLOGICAL HORIZONS OF PETROLEUM.

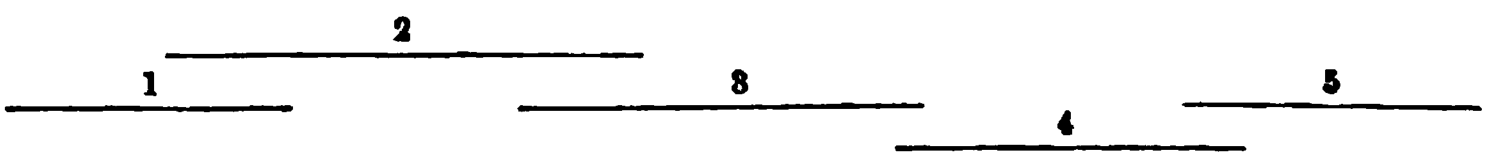
It is generally supposed that rock-oil exists in fissures or cracks running across the strata and extending obliquely or perpendicularly towards the surface; but this theory is contrary to experience and the nature of petroleum. In the first place, oil is always found on certain horizons,—below a special sandrock in Venango, and at a uniform geological depth in other localities; and, in the second, if oil existed in fissures, it would long ago have ceased to be oil, and become solid bitumen from the escape of the volatile parts.

In all oil-producing regions the strata are nearly horizontal, but having a gentle inclination and a basined shape; but all such basins are necessarily extensive, because the low angles of dip increase the distance between the outcrops. The natural position of oil in the strata is similar to that of coal. It occupies certain horizons between the strata, perhaps irregularly, but always below heavy, close-grained sandrocks, which are impervious to the escape of oil, and almost impenetrable to the most volatile gas, even under the highest state of tension: were it not so, but little oil could ever accumulate beneath them.

Beneath each heavy sandrock of Venango, and Northwestern Pennsylvania generally, is found a soft and yielding stratum of shale, slate, and mud. In these strata the gas and oil find a lodgement, as the first point of condensation. Arising through the rocks below in a gaseous condition, the nearer it approaches the surface the less volatile it becomes, and is arrested by the first impervious stratum.

The third sandrock of Venango, however, does not seal all the oil: the more volatile portions still find their way through the third and even the second sandstones, and form limited deposits of oil between them; but the lower or third rock seems to hold the great fountains of petroleum.

The stratum of oil thus formed may not occupy a perfect geological horizon, since the shale in which it is found varies in thickness, and the oil may find a cavity in any part of it,—at the bottom, in the middle, or at the top of the stratum. Though the drill must invariably penetrate the covering sandrock, it may not tap the fountains of oil at that depth. It is possible that the depth of wells almost side by side may vary 20 or 30 feet, or more, to reach the same oil-formation. A stratum of oil cannot be of great thickness. It may be only a few inches, or one and even two feet thick; but it may also be a mere streak, or the rocks may close or "pinch" it out entirely. Thus, the stratum may extend from ten to one hundred yards in width, and from a hundred yards to miles in length, or it may be even more limited or more extensive. It may change from a lower to a higher position in the shale, thus:



and the auger may strike a flowing well at 4, only a limited pumping well at 3, though but a few yards distant, and nothing in the shape of oil at 5.

If oil existed in fissures running obliquely or perpendicularly to the strata, it might be found at almost any depth from the surface, and in the most irregular manner, without regard to the sandrocks. But fissures in rocks existed naturally and originally as

vents for the internal heat or gases of the earth, and generally extended to the surface; and were these the reservoirs of oil, we cannot see how the light naphtha could be retained, since the volatile parts would escape through every crack or vent to the surface, and leave nothing but bitumen as a residue.

Figure 190 illustrates clearly the action of gas in producing the flow of petroleum from oil-wells. The stratum of oil, *f*, is always the lowest, while the gas, *b*, is always the highest, and occupies cavities in the shale invariably above those containing oil.

FIG. 190.

FLOWING WELLS.

DESCRIPTION.—*a*, flowing well; *b*, gas, and well-producing gas; *c*, *d*, *e*, sandrocks; *f*, oil-stratum.

These cavities, as before stated, are irregular; they may exist one above the other, or they may be located at considerable distances apart, and yet communicate, since the oil is the result of the gas in a condensed state: therefore a communication must exist between the reservoirs of oil and the gas producing them.

These gases always exist in a high state of tension, since this accumulation has been gradual and almost irresistible. In many cases, when struck by the auger and thus relieved, they have rushed forth from the well with the violence of exploded gunpowder, and have ejected the ponderous boring-tools out of the hole and to great distances from the spot. It is thus manifest that the pressure of the confined gases on the oil must be very great; and when the auger descends into an oil-cavity, without *first* striking its communicating gas, the pressure on the oil must cause it to rush up the auger-hole with great violence. But, if the gas be first cut in large quantities, of course it will flow up the hole independent of the oil. In case the hole is then continued into the oil, it will depend on the equilibrium of pressure: that is, if the gas forces its way through the vent first made by the auger with more violence than it bears on the oil, little or no flow will occur; but if the pressure be nearly on equilibrium, the flow will be intermittent. If the gas escapes through the upper or first vent, so as to relieve its pressure on the oil, then what oil may be struck must be pumped. If both oil and gas exist in small quantities, and the pressure or tension is, in consequence, weak, then pumps must also be used to obtain the oil.

FIG. 191.

GAS-WELLS.

Figure 190 illustrates both gas and flowing wells, when both exist in the same formation; but at a great depth gas alone is found, independent of petroleum; and figure 191 illustrates this. In its horizon or position gas occupies a higher stratum than oil, when both exist together, but when gas exists independent of petroleum, its geological horizon is found at a much greater depth and in a still greater state of tension, and when struck rushes forth with still greater violence, as demonstrated by the terrific outburst of gas from the deep wells on the Great Kanawha. But the great pressure of this deep gas forces small quantities of its most volatile parts through the minute crevices of the rocks to the surface, and if cavities are found in any slaty strata reservoirs of oil are formed, which constitute the upper or heavy oils of Kanawha. It may seem strange that so light a

gas should form this heavy oil, but it is produced on the same principle on which all heavy oils are produced, viz.: by the condensation of the gas and the escape of its most volatile parts. The carbon which constitutes from one-third to one-half the volume of this light gas has little or no affinity for hydrogen when in a cold condition: therefore the carbon condenses or separates from a portion of the hydrogen, leaving it free, and the result is a carbon oil, containing 85 carbon and 15 hydrogen. A further evaporation of the hydrogen leaves the carbon in all stages of density, from a heavy oil to bitumen and coal.

THE DISTRIBUTION OF PETROLEUM.

We shall say but a few words on this subject, since its distribution within the Great Basin has been pretty thoroughly discussed in the preceding pages, while its existence in volcanic regions has also been mentioned. Its general distribution through all formations and in all quarters of the earth is generally known. We will only call attention to a few localities where oil is found in conditions differing materially from those described.

The petroleum of Canada does not differ from that of Pennsylvania, though geologists assign it to the Corniferous limestone or the third oil-formation: on this subject, however, there is some disagreement, since others place it in the second formation, and on the same geological horizon with that of Venango. We have not given the subject much attention, and will not attempt to decide in which formation it is found. But whether its geological horizon be higher or lower, it cannot alter the fact of its existence in the same form and in the same circumstance and conditions as found in Venango county, Pennsylvania.

If it exists in the lower Devonian or upper Silurian, the rocks containing it come near to the surface where the Canadian petroleum is found, and, though the same formation may be over 2000 feet deep under Oil Creek, it is only from 300 to 500 where found in Chatham county, near Lake St. Clair, in Canada. At the greater depth under Oil Creek it would exist as gas only, but at the Canadian wells it would naturally be condensed as oil, from the escape of the hydrogen.

The oils of California and all or most of the great region west of the Rocky Mountains are principally, if not entirely, of volcanic origin, and exist in the vicinity of volcanic regions. The many scattered deposits of coal of a later date than the true Carboniferous prove the fact of their volcanic origin, since they are found in almost every lithological formation. Like the eastern coal-fields of Massachusetts, Virginia, and North Carolina, they were only created when the temperature of the great volcanic ranges in which they are located admitted of the condensation of the gases, which naturally must have been of much later date than in the comparatively temperate regions at a distance in the waters of the Great Basin.

We cannot refrain from noticing the fact again in this connection, to call the attention of the thinking reader to the uniformity and beauty of every coincident, when we refer the production of coal indirectly to the vapors of carbon, and directly to the resulting petroleum and bitumen.

We need not state that vapor or gases enshrouded the earth when a thousand volcanoes vented their streams of molten lava into the waters that filled its deep places; nor need it be argued that the vapor of carbon and the hydrogen of water should unite under the heat produced, forming carburetted hydrogen gas.

This could not result in oil under the heat that existed in the vicinity of volcanic action; but at a distance, where the molten lava, shivered by its contact with water, precipitated as sediment in the waters of the wide Appalachian basin, the temperature would be much reduced, and the carbon would part with much of its hydrogen, and become in consequence petroleum.

In every great coal-field known, a process similar to this took place. In the Welsh anthracite field it was almost identical, and in the Great Northern coal-field of Northumberland and Durham in England, while the manner of its production might have been quite different, the principle was the same. There the oil forming coal might not be derived from distant sources of heat, but the great dikes penetrating the coal-field might have produced the vapor and gas of the hydro-carbons. These dikes are of all ages. The "whin-sill" underlies the coal, while the great ninety-fathom dike reaches the surface. At some points the coal has been formed on the dikes, and of course subsequent to their formation; while at others the trap invades the coal measures from bottom to top.

The debris forming the rocky strata may have been partially derived from the volcanic dikes piercing the field, but in all probability the sedimentary matter was derived from more distant sources. It is not essential, however, to the correctness of the theory given that the hydro-carbons should be derived in part or in whole from the heat of local volcanic action, nor do we feel at all confident that such was the case. It is equally or perhaps more probable that both the regions of heat and the sources of the rocky material were remote from the English fields of bituminous coal. We find our Western coal-fields and the accompanying strata over a thousand miles from their sources of production.

Petroleum has been produced and utilized for centuries in Burmah, and it is reported the production has amounted to over half a million barrels annually. The wells do not appear to be deep, but are generally large excavations, into which the oil rises continually, giving off its more volatile parts and remaining as a heavy oil. Nothing positive has come beneath our notice in regard to the geology of this district, though it has been said that small seams of impure coal or bitumen exist below the oil-wells. Our impression is that it must be a volcanic region, and that the oil is constantly produced as it is produced in Cuba and Trinidad, rising from the volcanic sources of heat through the strata to the surface.

The naphtha of Persia has been celebrated for a long period, and has been used for sacred oblations and light in the pagan temples for ages. It is lighter than the Pennsylvania petroleum generally, but about the consistency of the oils produced from our deep wells. In regard to the formation and geological character of the Persian naphtha we can say nothing.

In China petroleum has been long used. It is found in several localities; but we have only one to note, in which it exists in much the same geological condition and position as it is found on the Great Kanawha in connection with coal and salt. The oil is very light when first exposed, or when found at a great depth from the surface, but becomes thick on exposure. Gas is frequently struck in the salt-wells, which are often over 1500 feet deep; and sometimes its discharges are so violent and terrific as to suspend all operations in the vicinity.

When the gas thus emitted becomes ignited, the effects are tremendous and fearful, as shown by late experience in Northwestern Pennsylvania, and by former accidents on the Great Kanawha.

DISTILLATION OF COAL-OIL.

We have collected and prepared a large quantity of materials on the subject of petroleum and coal-oil,—enough, in fact, to fill a work as large as the one before us; but both time and space admonish briefness, and we are necessarily forced to abandon the idea of presenting an exhaustive treatise, or even an epitome of the many subjects that naturally present themselves for examination.

Though many have written on these subjects, none have examined and discussed

them practically, and there yet remains much to be said and learned in regard to their utility, as well as their character and productions. A work on this subject could not fail to be interesting and useful. We have searched in vain for something practical in relation to the origin of petroleum and coal oil, but have read or heard of no publication of the character desired. Many of the books published on these subjects, however, are interesting, and present information new to the public; but most of them are rambling, indefinite, and far from satisfactory.

COAL AND COAL-OIL.

The common varieties of mineral coal are divided into several classes, according to their density and the volatile or bituminous matter they contain. Hard anthracite is the most dense and contains the most carbon. On the Lehigh and through a great portion of the eastern end of the First and Middle coal-fields the density of anthracite is about 1500, water being 1000, and its constituents are—carbon about 90 parts, water and volatile matter from 5 to 6 parts, and earthy impurities from 4 to 5 parts.

The density of the Wyoming coals is rather less than the above, while the volatile matter is a little more. In the western end of the First and Middle coal-fields the density of the coal, which is a semi-anthracite, is about 1400, and its constituents, carbon 85 to 88, volatile matter 8 to 12, and earthy impurities 5 to 8.

The semi-bituminous coals of Broad Top and Cumberland have a density of 1300 to 1400, and their constituents are—carbon 75 to 85, volatile matter 10 to 20, and earthy impurities from 5 to 7. The rich bituminous coals of the West have a density of 1200 to 1300; their constituent parts are—carbon 50 to 60, volatile matter 35 to 48, and ashes from 2 to 6. Cannel coals are usually a little lighter than the common bituminous, and contain more volatile matter, frequently as high as 50 and even 60 per cent.

Coal-oil and illuminating gas are made only from the two last-named coals,—the rich bituminous or the richer cannel,—not because it is impossible to turn the former back into oil or gas, but because under present development it has not been considered practical, and because the richer bituminous coals can be made to give up their volatile matter with more economy. We presume our coal-oil manufacturers will scarcely realize that nearly the whole mass of the coal *can be* reduced to oil; but such is the fact. The present mode of destructive distillation is extremely wasteful and expensive. We have shown that all valuable coal is composed of from 90 to 98 per cent. of carbon and volatile matter,—principally hydrogen; but when the volatile matter is very great, perhaps oxygen and nitrogen may form small portions of the volatile constituents of coal. It has been demonstrated that the solid body of coal was produced from gas or gases, first condensed in the form of oil, and subsequently solidified by the evaporation of the most volatile parts. Coal, therefore, is a solidified gas, which may be again resolved into its original condition by heat, and again condensed to oil and solidified as coal by the natural process. That loss will take place in the practical treatment is evident, since much of the rarefied vapor would escape; but the process which produces only 40 gallons of oil from a coal containing 50 per cent. of bituminous matter, which should produce over 100 gallons, is certainly far from perfection. When we consider, however, that the entire mass of coal, excepting the earthy impurities, may be reduced to gas, and again condensed into oil, we find how very far we are from the perfect chemical processes of Nature. Yet we think they may be imitated with success and economy. The cost of obtaining 100 gallons of oil from a ton of cannel coal should not be greater than that now sustained in the production of 40 gallons; and perhaps we may be safe in stating that double the quantity of oil specified, or 200 gallons of oil, may be produced from a ton of rich cannel coal, and proportionate amounts from coal of a less pure variety.

Oil may be produced from anthracite and semi-bituminous coals; but it is a question whether any process which could be adopted would pay as a practical operation.

Our view of the matter may be stated in a few words. Nature has produced and stored away for man a vast amount of carbon in various forms,—as gas, as oil, as bitumen, and as coal. It seems contrary to the rules of chemistry and the laws of reason that we should let the gas from which she produced oil and coal go to waste, while we convert the coal back into gas and then into oil. Would it not be more practical and economical to convert the waste gases into oil, rather than the coal into gas, and this coal-gas into oil? The question may be asked, Can it be done? We think it can, and we hope to demonstrate the fact. But it cannot be done here and now, since patents are pending on the processes, and neither our space nor time would permit their discussion in this connection.

It is not practical, however, to obtain free gas in all localities; but in all coal-fields gas may be obtained by boring to the proper depth, even in the anthracite regions where petroleum does not exist; but there it would be very deep. In localities where subterranean gas cannot be obtained, both gas and oil may be produced from coal with more economy than oil can be supplied under present development: but our impression is that our resources of hydro-carbons, in the shape of petroleum and petroleum gases, principally within the Alleghany coal-field, are equal to any demand, and that oil produced from gas may yet supply light to cities and towns, villages and private houses, with more economy than it can be produced from the richest cannel coal.

We before observed that both the carbon and the bitumen of coal may be reduced to vapor or gas, and that this may be condensed in the shape of oil. The manner of converting subterranean gas to oil would be nearly similar to that employed in the reduction of coal-gas, and the chemical action is a close imitation of the processes of nature, in which water and air act principal parts, while heat and cold, in combination with mechanical power, expands or condenses the coal or the gas. The *modus operandi* and the mechanical means are not necessarily confined to one single mode. Every chemist and mechanic knows how various are the processes or modes frequently used in accomplishing the same object.

The aim of the practical and experienced is always towards economy and simplicity. One mode may be very beautiful and attractive in theory, but very expensive and profitless in practice. It is, therefore, of the first importance that the simplest and most economical modes and processes be employed in all practical operations when they can be made available; but, as before stated, we cannot here illustrate the various modes of distilling coal-oil now in use, or those which may be more available; while the process of condensing or utilizing petroleum gases would be still more difficult to explain for practical purposes in the space now at our command. The hints we have given may set practical men to thinking, and to an investigation of the subjects discussed, and which may lead to useful results. We propose, however, to elaborate these subjects fully in a future publication, when experiments now in process of operation shall have demonstrated the most practical processes both of the distillation of coal and the condensation of gas.

The modes now practised for the distillation of coal and other bituminous substances, and the production of coal-oil therefrom, are both expensive and wasteful; while the refining of the crude oil, whether petroleum or coal, is complicated, costly, and imperfect.

CONCLUSION OF PETROLEUM.

This may seem a hasty and unsatisfactory conclusion of one of the most important subjects of this work,—one which perhaps we ought to have commenced with; and

were we to rewrite the book such would be the order in which we should arrange the subjects, since petroleum naturally precedes coal, and should receive the first attention. Many of our readers, who are more interested in oil than coal or iron, may be disappointed at this abrupt termination, without any reference to the practical operations of boring for and producing oil. We can only plead that our limits have been greatly exceeded, and we are now forced to a conclusion *nolens volens*.

In discussing the subject of petroleum, however, we have kept off the beaten ground of other writers, and have presented it in such a manner as may lead to a correct appreciation of this comparatively new source of our mineral wealth, and its economical and practical development; while the many facts in relation to the hydro-carbons, so clearly demonstrated in that portion of this work devoted to the formation and origin of coal, prove the correctness of our otherwise theoretical conclusions, and present unmistakable evidence of the identical origin of COAL AND COAL-OIL.

THE END.

With a few brief words we must conclude this, the principal part of our work, and reserve for the APPENDIX our statistical tables, descriptions of mines, and such other information as require frequent alterations from annual additions and changes. The main portion of the book, or 674 pages, is in electrotyped plates; but the APPENDIX is not electrotyped.

In concluding our long and arduous labors, we feel inclined to recapitulate and present an epitome of the subjects discussed; but fear to do injustice to both ourselves and our readers, since the whole work is condensed and concise, and nothing less than a revision of the whole would present a fair or just compendium.

A partial or minute statement would convey but an indefinite idea of the book, while even a brief synopsis would occupy more room than we can now spare. We would therefore respectfully refer to our Preface, Table of Contents, and concluding Index of Subjects, as the best epitome we can present. Every subject will be found under its appropriate head and in the order of their occurrence.

The VOLCANIC THEORY herein advanced will give a new and, we hope, a correct starting-point to the science of geology. We have always thought the main theories of the science to have been conceived in error by modern sophists and infidels, who invented them as arguments against the truth of revelation and the Bible. Even those who have battled manfully and successfully for the truth seem to have accepted the theories framed by its adversaries, and sought no other guide to the NATURAL PROCESSES of Creation.

We cannot resist quoting the words of an old and celebrated Cornish miner, whose implicit faith in the truth of revelation made him its staunch defender and a powerful opponent to its revilers. We do not endorse all his sentiments, nor embrace his sweeping denunciations of geology and geologists; but we do think, as he did, that the science was not only conceived in falsehood, but against the truth, by the enemies of religion, and that it has been developed under all the difficulties of the original error. The science itself we consider the grandest study open to the human mind, and its great masters, who have elucidated so many wonderful truths from its dark arcana, are entitled to our highest respect and admiration. Nevertheless, our voice is given against the errors of infidelity, whether adopted by geologists or the teachers of men; for we believe that the WORKS of CREATION will agree with the WORD of GOD.

"Permit us to inquire what benefit mining has received from all the writings, lectures, societies, premiums, researches, and labors of our large body of theoretical geologists? If I am wrong, please to set me right; but, I declare, I know not a single instance where any good has emanated from their exertions, to the value of a swabbing-stick! All the

progress made in the discovery and working of mines has been without their help; the ancient methods of detecting or identifying a metallic vein by shodes, gossans, mineral waters, gases, &c. have received no improvement from them, although we are persuaded that a fine field for art and science is still open here; for, as *nature always works by general laws*, we believe that if all the indications which attend a rich metallic vein could be detected, that mining would not be so much a speculation as it is at present. But what can be the cause that such a large body of talented men, devoted to the subject, ambitious to excel, and 'with all appliances and means to boot,' should be thus notoriously useless and unprofitable? Now, Mr. Editor, allow me to observe that *theology* should ever be the basis of geology. This, sir, is the grand cause why the efforts of our geological societies have utterly failed: they have set themselves against the *truth*, they have rejected the inspired history of the creation of the world; hence their writings and sayings are replete with error, inconsistency, and contradiction.

"Let them begin again, cancel what they have written, and lay their foundation on the sublime account given us in the Scriptures. Then let them follow Nature in all her grand and stupendous subterranean operations, and they will discover a world of harmonious wonders, and will bring to light, to the admiration and benefit of mankind, the cause and effect of the magnificent order of every part of creation that is allowed to fall under the inspection of man.

"I shall be borne out in stating my firm conviction that no skeptic ever made a good geologist; and, whatever those men may think of themselves who dare to write in contradiction to the Word which the Creator has graciously condescended to bestow on his creatures, they are no better than practical atheists in the judgment of all men 'who believe and know the truth,' and their writings are calculated to inflict a serious injury on society and sap the foundations of Christian faith."*

* Budge's Miner's Guide; Letter to the "London Mining Journal."

APPENDIX;

CONTAINING THE

STATISTICS

OF

COAL, IRON AND OIL.

I.

THE STATISTICS OF THE PRODUCTIONS OF IRON IN THE UNITED STATES AND EUROPE.

II.

STATISTICS OF THE PENNSYLVANIA ANTHRACITE COAL TRADE; THE BITUMINOUS TRADE OF THE UNITED STATES, AND THE COAL AREA AND COAL PRODUCTIONS OF THE WORLD.

III.

DESCRIPTIONS OF THE ANTHRACITE MINES OF PENNSYLVANIA, &c.

IV.

STATISTICS OF PETROLEUM.

V.

ADVERTISEMENTS.

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PART VIII.

APPENDIX.

This portion of the Book will be devoted almost exclusively to statistical statements, descriptions of mines, manufactures and places, and business matters generally.

It was intended, when this work was commenced, to illustrate its text and sustain its arguments, by notes, from various authorities, in the Appendix; but, though a large quantity of manuscript has been prepared for this object, we are compelled to reject the whole for want of space.

We proposed, in page 35, to trace a parallel between Geology and the Bible, as given in the Mosaic account of Creation, and on page 81 we promised to give Professor Rogers' theory of coal formation in this portion of our work; but we are compelled to omit both, for the reasons assigned, though the copy was prepared for the printers. Professor Rogers' theory may be found on page 805 of his great work on the Geology of Pennsylvania.

NOTES AND EXPLANATIONS.

Note I.

THE CONGLOMERATE ROCK OF THE COAL MEASURES.

On page 57, in describing this rock we were induced to follow the theories of Rogers and Lesley in regard to its origin and formation,—first because we have much confidence in Professor Lesley's opinions; and, second, because the arguments presented seemed to justify the conclusion. But even Lesley is undecided on this question. He says, in his Manual of Coal, page 73: "But after disposing of all these arguments, *concretionary* quartz remains a *possibility*, and some as yet unknown method of explaining its susceptibility to impressions is a great desideratum."

Professor Brainard, of Cleveland, maintains, by many strong arguments, that the pebbles of the conglomerate rock are *concretions*, and the precipitate of a solution of silex, or feldspar and mica, formed by the chemical action of lime, &c. These pebbles are always smooth, as if formed by detrition, like those of a shore or stream; but, unlike the latter, they present *no* angular surfaces; those which are not wholly smooth are crystalline; they are generally flattened, and always imbedded

on their flat surfaces, as shown in figure 5. They are often pitted as if marked while in a soft condition, and sometimes contain impressions of plants, which must have been produced while the pebbles were in a soft condition. These and other considerations, which we will state below, induce us to conclude the conglomerate rock to be precipitated during a time of volcanic quiet, and that the white pebble are concretions of silex.

The immense horizon of this rock; its uniform spread, yet gradual depreciation both in thickness and coarseness westward and northwestward, indicate its source as identical with that from which all or most of the material filling the Great Basin was derived. We said, on page 57, that "it evidently could not have been of volcanic origin, since there appears to be little or none of the pure igneous rocks in the mass." This, we must state, is erroneous in fact, though correct when considered as a purely sedimentary formation, produced by the detrition of existing rocks; but we have persistently advanced the theory of the volcanic origin of all our rocky strata, whether clay, slate or sandstone; yet these rocks contain no evidence of direct volcanic eruption. The Red-shale, on which, and in which the conglomerate pebbles are frequently imbedded, does not appear to be derived from volcanic sources, and yet that such is its source cannot be successfully denied, though at the time of its precipitation violent volcanic action did not take place except at intervals, but the ashes, dust and smoke of their smouldering quite filled the air and the waters with a fine sediment, intermixed with the coarser strata of intermittent eruptions. To be consistent, we must therefore repudiate the theory of *detrition*, as stated on page 57, and accept the more natural one of *concretion*, to account for the white pebbles in the conglomerate rock.

Note II.

ROCK FAULTS.

On page 295 we stated our inability to account for a certain class of rock faults, shown in figure 110, in which the rock occupies narrow walls across the plane of the coal, sometimes only a few feet in thickness, dividing the coal in the form of a dike, and yet not injuring the size of the bed or the quality of the coal. We find the coal on each side of these peculiar faults perfectly pure, but abruptly terminating against the face of the fault. These faults rarely extend above or below the coal. They simply divide the bed, and are always composed of the same material, whether slate or rock, which forms the "roof" or strata covering the coal-bed.

In tracing the evidence offered by existing facts, to prove that mineral coal is the result of petroleum, or a solidified hydro-carbon, we find the rock faults alluded to satisfactorily explained by the fact that the bitumen resulting from the evaporation of the lighter portions of petroleum on the surface of the water, frequently exhibit *cracks* or *fissures* across its surface for great distances, as shown by the pitch lakes of Trinidad and other places.

These cracks or fissures would naturally become filled with earthy matter, and form the rock faults just as we find them.

No other theory can satisfactorily account for the peculiar faults herein discussed, and the natural and clear explanation thus afforded offers another proof of the formation of our coal-beds from the condensed hydrocarbon. With the facts now before us, and the vast amount of evidence gathered in our patient and laborious

investigation of this subject during the two years we have devoted to this work, we could now present our theory of the NATURAL PROCESSES, and the formation of mineral coal, much more clearly and satisfactorily than they have been presented in COAL, IRON and OIL, but we must now let it stand as written. We did not set down to prove a peculiar theory, but the theory grew into shape and being, by the facts which were developed by a close investigation, and by thirty years of former experience and extensive practical observation.

NOTE III.

COAL-BEDS OR SEAMS *vs.* VEINS.

The anthracite coal miners invariably, though erroneously, apply the term "vein" to denominate the anthracite beds, and we have followed them in using this arbitrary term, because it has become a technicality, or mining phrase, in the anthracite regions, which cannot be now changed as a common name. Beds are, perhaps, the most proper name by which to designate our coal strata. In England they are generally known as "seams," while in the western and southern States the coal-beds, as well as the coal-mines, are known generally as "coal-banks." In writing of other coal-fields, or those not in the anthracite regions, we have generally used the term "seam," but coal-beds are more appropriate. The name vein was derived, perhaps, from the Cornish miners, who knew no term but *lode* or *vein* for all kinds of mineral deposits or formations.

NOTE IV.

ROGERS' NOMENCLATURE.

We have frequently made use of Professor Rogers' nomenclature of the Palæozoic strata of the Appalachians in this work. On page 36 will be found the Palæozoic column in Pennsylvania, and the equivalents of Rogers' divisions in New York and England.

NOTE V.

THE GREAT BASIN.

Figure 117, page 323, represents the Great Appalachian or Mississippi Basin. We have given this Great Basin various names in discussing the formation of the palæozoic strata therein. First we call it the "Ancient Sea," because it was occupied or filled in the beginning, from the granite coast range of the east to the Rocky Mountains, by water, and existed as a sea. We also call it the "Great Inland Sea," because it gradually became less in extent, and retreated inland, by the rapid accumulation of the sedimentary strata in its eastern and south-eastern portions. It is also known as the Appalachian Basin, and this, perhaps, is the most comprehensive term, since no other name seems to be applicable as a cognomen for the entire basin. This term, however, is arbitrary, and originally applied to the mountain ranges on the eastern side of the basin. The "Mississippi Basin" is a name sometimes given to the entire formation, though properly it is applicable only to that portion of the basin drained by the waters of the Mississippi.

SECTION I.

STATISTICS OF IRON.

The following data and statistical tables concerning the iron trade of the United States are compiled from the publications of the American Iron and Steel Association, by permission.

The late Secretary, Dr. Robert H. Lamborn, has divided the Anthracite Iron Manufactures into five districts, for convenience of reference and tabulation, and with much industry has completed a set of elaborate and comprehensive tables, from which the following are merely abstracts:

1st, or LEHIGH GROUP OF FURNACES.

See Tables 1 *and* 2, *pages* 684 *and* 685.

In 1849 the Lehigh region produced but 44,347 tons of metal, being an average of 4,434 tons for each furnace in blast. In 1860, the year before the war, they produced 173,075 tons, while in 1864, the last of which we have definite information, their production reached 214,093 tons, an average of 7,929 for each furnace. Their total annual capacity in 1860 was 176,166 tons. In the present year they are capable of producing 267,116 tons. This region consumed in 1864, 486,105 tons of ore, and 459,051 tons of anthracite coal: a consumption of about two and one-third tons of ore, and two and one-seventh tons of coal for each ton of iron made. Of the thirty furnaces in this group, twenty-two are now in blast.

2d, or SCHUYLKILL GROUP OF FURNACES.

See Tables 3 *and* 4, *pages* 686 *and* 687.

Of the twenty-four furnaces in the Schuylkill group, twenty are now in blast. In the year 1849 this region produced 23,436 tons of metal, being an average of 2,929 tons for each furnace in operation. In 1860 they produced 92,345 tons, and in 1864, 112,806 tons, an average of 5,372 tons per furnace. In 1850 the total capacity of the region was 42,000 tons. In 1864 there were 259,000 tons of ore and 227,000 tons of coal consumed, a consumption of about two and three-tenth tons of ore, and two tons of coal for each ton of iron.

3d, or LOWER SUSQUEHANNA GROUP OF FURNACES.

See Tables 5 *and* 6, *pages* 688 *and* 689.

Of the thirty-two furnaces comprising the Lower Susquehanna group, twenty-two are now in blast. In 1849 this region produced 24,256 tons of pig metal, an aver-

age of 2,694 tons per furnace in blast. In 1860 they made 101,246 tons, and in 1864, 118,615 tons were produced, averaging 4,394 tons per furnace. The capacity of these furnaces in 1850 was 72,400 tons; they are now able to produce 170,861 tons. In 1864 this region consumed 271,762 tons of ore and 228,886 tons of coal, a fraction over two and one-third tons of ore, and about two tons of coal for each ton of iron made.

4TH, OR UPPER SUSQUEHANNA GROUP OF FURNACES.

(ABOVE HARRISBURG, AND ON THE JUNIATA.)

See Tables 7 *and* 8, *pages* 690 *and* 691.

Of the twenty-nine furnaces in the Upper Susquehanna group, sixteen are now in blast. In 1849 this region produced 26,625 tons of iron, an average of 2,420 tons per furnace in blast. In 1860 the production was 69,698, which was increased in 1864, 108,664 tons, an average of 5,174 tons for each furnace in operation. The utmost capacity of this region in 1850 was 58,700 tons. The present year it is capable of producing 167,500 tons. Eight furnaces in this group have been idle for a number of years, and it is not likely that they will again be put in blast. In 1864 the furnaces in this region consumed 261,015 tons ore and 213,477 tons coal, being two and two-fifths tons of ore, and about two tons of coal for each ton of iron manufactured.

5TH, OR EASTERN GROUP OF FURNACES.

See Tables 9 *and* 10, *pages* 692 *and* 693.

The eastern group, comprising all the anthracite furnaces east and north of Pennsylvania, excepting the Cooper furnaces in New Jersey, which more properly belong to the Lehigh region. Of this group New Jersey contains one, New York twenty-four, Connecticut two, and Massachusetts three furnaces.

In the eastern group there are thirty-one furnaces, of which ten are now in blast. The cause of the general inactivity in the valleys of the Hudson and Housatonic rivers is attributed to difficulties among the miners and the high price of coal. In 1854 the furnaces comprised in the eastern group produced 47,158 tons of pig metal, an average of 3,930 tons for each furnace in blast, twelve being then in operation. In 1860 they produced 88,167 tons, and in 1864, 130,140 tons, being an average in 1864 of 5,911 tons per furnace in blast.

The utmost capacity of these works in 1850 was 36,000 tons. Their estimated capacity the present year is 201,841 tons; in 1864, 242,485 tons of ore and 256,147 tons of coal were used, a consumption of two and three-tenths tons of ore, and two tons of coal for each ton of iron made. Of the total production in 1864 of anthracite pig iron, there was produced in Massachusetts, 2,509 tons; New York, 120,463 tons; New Jersey, 29,578 tons; Pennsylvania, 521,391 tons; Maryland, 10,378 tons.

BITUMINOUS COAL AND COKE FURNACES.

The total production of the raw bituminous coal and coke furnaces for 1864 was 210,108 tons, of which Pennsylvania produced 121,860 tons; Maryland, 1,717 tons; Western Virginia, 3,800 tons; Ohio, 82,731 tons.

CHARCOAL FURNACES.

Our data in regard to charcoal furnaces is limited. The total productions of charcoal pig during 1864 in the Northern States amounts to 255,486 tons. The amount produced in the Southern States during 1864 can only be conjectured. There were about twenty furnaces in blast in Virginia during 1863–64; ten in North and South Carolina; five in Georgia, and ten in Alabama. These produced on an average about 1000 tons of pig-iron per annum, or five tons per day, for a blast of two hundred days, making the total amount of cast, or charcoal pig-produced, about 55,000 tons. . In addition to the iron thus produced, a considerable quantity of wrought iron was produced in the numerous Catalan forges and bloomeries erected in Virginia, North Carolina, Georgia and Alabama.

CHARCOAL PRODUCTION OF PENNSYLVANIA.

In 1849 there were seventy-nine charcoal furnaces in Pennsylvania east of the mountains, which produced in that year 55,617 tons. By the year 1860 thirty-two of these had finally ceased operations. To the remaining forty-seven at least seven new furnaces had been added; the production in that year was 36,576 tons. In 1864, 42,953 tons were made. West of the Allegheny Mountains, in Pennsylvania, there has been since 1849 a very marked and rapid decrease in the production of charcoal iron. This region in 1849 produced 55,494 tons of charcoal iron, eighty-five furnaces being in operation. In 1864, nine furnaces only were in blast, producing 8,701 tons. This remarkable decrease in the quantity of charcoal iron made in Pennsylvania can be ascribed to the operations of several agencies:

1. The absorption of wood for agricultural and other purposes.

2. The great demand and consequent high price of labor.

3. The extensive introduction of the manufacture of Iron from coke and raw coal. These causes, operating with more or less intensity throughout the Eastern States will, probably, gradually drive the charcoal iron manufacture into the Western and Northwestern States, where wood is cheap, and where the ores are of unexampled purity and richness. The total production of charcoal pig-iron in the country, in 1864, amounts to 255,486 tons.

ROLLING MILLS.

			Total Produced.	Present Capacity.
Massachusetts	2	Rolling Mills	30,312	37,000
New York	5	"	57,433	98,000
New Jersey	1	"	11,687	12,000
Pennsylvania	14	"	159,610	318,000
Maryland	2	"	5,488	29,000
West Virginia	2	"	844	18,000
Ohio	3	"	20,301	36,000
Kentucky	2	"	4,441	26,000
Indiana	1	"	12,773	30,000
Illinois	3	"	26,880	80,000

			Total Produced.	Present Capacity.
Michigan	1	Rolling Mill	5,600	20,000
Missouri	1	"		10,000
Tennessee	1	"		9,000
Georgia	1	"		9,000
			335,369	732,000

In 1850 the production of the roll-mills in the country was 29,083 tons—six mills only having been built and in operation. These mills have 936 furnaces, classified as follows:

Double-puddling furnaces	250
Single-puddling furnaces	352
Heating furnaces	333

These have 131 trains of rolls, 37 of which are "three high." The increase during the last year has been as follows: In 1857 re-rolled 56,450 tons; in 1864 it amounted to 177,203 tons, the increase being gradual yearly.

STEEL WORKS.

There are thirty-seven steel manufacturers in the United States, and the total production of all kinds of steel amounted to 18,000 tons, as follows:

Massachusetts, 450 tons; Connecticut, 100 tons; New York, 2,500 tons; New Jersey, 3,700 tons; Pennsylvania, 11,500 tons.

The works in the city of Pittsburg produced about one-half of the steel manufactured in the country. The capacity of our steel works is not less than 48,000 tons per annum.

RÉSUMÉ.

The product of the blast furnaces in 1864 was 1,149,913 net tons.* Of this, 684,319 tons were anthracite pigs, 210,108 of raw coal make, and the balance of charcoal make. The product of Pennsylvania and Ohio exceeded one million tons.

In 1856 the whole number of charcoal furnaces in the United States was 156.

The amount of pig-iron, scrap-iron, &c., worked up in 1864 was about 1,400,000 tons. It is evident that this important interest is to be largely developed here in the next few years, and it is the duty of the Government to extend to it every encouragement.

STATISTICAL TABLES.

The following Statistical Tables of the Anthracite Furnaces of the United States are compiled from the publications of the American Iron and Steel Association:

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* Including the Southern States this is increased to 1,300,000 tons.

No. 1.

THE LEHIGH GROUP OF ANTHRACITE FURNACES.

NAME OF WORKS AND POST OFFICE ADDRESS.	No. of Furnace.	FURNACES.			BLAST.				STEAM POWER. 40 to 60 lbs. pressure.			
		Date of Erection.	Height in Feet.	Width of Bosh in Feet.	Heat of Blast. In degrees.	Pressure, Square Inch.	Number of Tuyres.	Diameter of Tuyres. Inches.	Water Wheels.	Steam Engines.	Diameter of Steam Cylinder Inches.	Length of Stroke. Inches.
Cooper Furnaces..............Phillipsburg, N. J...	1										36	72
" " .... " ...	2										36	72
" " .... " ...	3										42	72
Durham Furnaces............Reiglesville, Pa......	1										30	72
" " .... "	2										30	72
Glendon Iron Works.........Easton, Pa.............	1											
" " .... "	2										30	96
" " .... "	3											60
" " .... "	4											
Bethlehem Iron Works......Bethlehem, Pa.........	1										72	96
Roberts Iron Works..........Allentown, Pa.........	1										30	72
" " .... "	2										36	96
Allentown Iron Works......Allentown, Pa.........	1										40	96
" " .... "	2										40	96
" " .... "	3										40	96
" " .... "	4										46	94
Lehigh Crane Iron Works..Catasauqua, Pa......	1										36	75
" " "	2										40	108
" " "	3										40	108
" " "	4										56	120
" " "	5										60	120
Thomas Iron Works.........Hokendauqua, Pa....	1										56	108
" " .... " ...	2										56	108
" " .... " ...	3										66	120
" " .... " ...	4										66	120
Lehigh Val. Iron Works...Laubach's P. O., Pa.	1										36	72
" " ... " ...	2										40	54
Carbon Iron Works..........Parryville, Pa.........	1										36	54
" " .... "	2										40	54
Manch Chunk Furnace......Abandoned	1										60	60
Totals..												
Averages..											42[illegible]	91[illegible]

No. 2.

THE LEHIGH GROUP OF ANTHRACITE FURNACES.

NAME OF WORKS. Beginning with the most easterly.	CAPACITY. Tons of 2000 lbs.			Production in 1864. Tons of 2000 lbs.	Weeks in Blast in 1864.	CONSUMED AND EMPLOYED IN 1864.					
	In 1850.	In 1857.	In 1865.			Ore. In Tons of 2000 lbs.	Flux. In Tons of 2000 lbs.	Anthracite Coal In Tons of 2000 lbs.	Men and Boys employed.	Horses and Mules employed.	Capital invested.
Cooper Furnaces,...		8,960			40						
" "		7,840	30,000	22,410	52	47,574	16,491	47,226	182	10	$300,000
" "		8,960			32						
Durham Furnaces...	8,960	6,160	12,000	4,979	52				90	41	162,500
" " ...	......	6,160		1,840							
Glendon Iron Works	4,480	6,600	9,500	7,682	38	15,348	8,764	13,373			
" "	7,056	7,840	8,600	8,422	52	17,492	10,183	14,897	...	...	600,000
" "	7,056	6,160	9,500	9,476	52	19,210	11,379	17,062			
" "	3,920	7,840	8,600	7,149	46	14,318	8,536	13,495			
Bethlehem I'n Wks,	......	......	10,000	9,830	49	22,017	11,944	18,746	200	...	200,000
Roberts Iron Works,	......	......	6,116	3,894	28	10,653	6,016	9,383	21	4	400,000
" "	......	......	8,400	......	...	....	....	....			
Allentown Iron Wks	5,600	5,040			52						
" "	5,600	5,040	30,000	26,162	...	61,500	36,000	56,000	450	65	600,000
" "	......	7,840			52						
" "	......	7,840			52						
Lehigh Crane I'n W.	4,480	5,824			52						
" "	5,600	6,720			52						
" "	8,064	8,960	50,000	41,774	45	99,416	55,319	109,054	600	54	1,000,000
" "	8,960	10,640			52						
" "	8,960	10,640			39						
Thomas Iron Works	......	10,640		13,492	52						
" "	......	10,640	50,000	9,134	40	117,600	75,000	109,700	800	75	1,000,000
" "	......	......		13,963	52						
" "	......	......		13,226	52						
Lehigh Val. I'n Ws.	......	6,720	16,200	10,560	45	34,597	19,109	27,246	70	15	300,000
" "	......	......									
Carbon Iron Works,	2,240	3,360	18,000	10,000	42	26,380	14,919	22,869		13	300,000
" "	......	......		......	10						
Mauch Chunk Fu'ce,	2,240	2,800	......	......	...	....	....	....	...	...	....
Totals...............	76,166	168,224	267,116	214,093		486,105	273,660	459,051	2,413	277	$4,862,500
Averages..........	5,859	7,314	9,238	8,929	45½	18,734	10,525	17,665			

No. 3.

THE SCHUYLKILL GROUP OF ANTHRACITE FURNACES.

NAME OF WORKS, LOCATION AND POST OFFICE.	No.	FURNACES.			BLAST.				POWER 40 to 50 lbs. pressure.			
		Date of Erection.	Height in Feet.	Width of Bosh. In Feet.	Heat of Blast. In Degrees.	Pressure. Square Inch.	No. of Tuyres.	Diameter of Tuyres. Inc's.	Water-Wheels.	Steam Engines.	Diameter of Steam Cylinder. Inches.	Length of Stroke. Inches.
Wm. Penn Furnaces.........Norristown, Pa.......	1	1844	37	11½	400	3½	3	4	0	1	20	72
" " ....Conshohocken, Pa...	2	1853	52	14½	400	5	4	4	0	1	36	96
Spring Mill Furnace.......... " " ...	1	1844	40	12	600	3½	3	3½	0			
Merion Furnace................ " " ...	1	1849	39	12	400	4	3	4	0	1	24	72
Plymouth Furnaces.......... " " ...	1	1845	42	14	450	4	3	4	0	1	72	72
" " .... " " ...	2	1864	42	11								
Swede Furnaces............... Swedeland St., Pa...	1	1850	42	14	400	4½	3	4	0	1	33	84
" " ....Norristown, Pa.......	2	1853	42	14	400	5	3	4	0			
Lucinda Furnace.............. " "	1	1856	36	10	400	3	3	2½	0	1	22	48
Montgomery Furnace........Port Kennedy, Pa...	1	1854	40	14	400	5	6	3½	0	2		
Phœnixville Furnaces.......Phœnixville, Pa.....	1	1845	38	12	500	4½	3	3½				
" " .... " "	2	1845	38	12	500	4½	3	3½				
" " .... " "	3	1847	38	14	500		3	3½				
Monocacy Furnace..	1	1856	36	12			3	4				
Keystone Furnace.............Birdsborough, Pa....	1	1854	45	12	450	4	3	3½				
Reading Furnace..............Reading, Pa...........	1	1854	49	18	600	6½						
Henry Clay Furnaces........ " "	1	1845	38	14	400	5½	6	2¾	0	1	22	72
" " .... " "	2	1854	38	14	400	5½	6	2¾	0	1	26	72
Robesonia Furnaces..........Berks Co., Pa..........	1	1846	30	9	400	3½	3	2¾	0	1	23	60
" " .... " "	2	1856	38	13	400	3½	6	2¾	0	1	24	72
Leesport Furnace...............Leesport, Pa...........	1	1853	45	14	600	3½	3	2¾				
Moselem Furnace..............Nora, Pa.................	1	1823	34	9			3	3				
Pioneer Furnace................Pottsville, Pa..........	1	1853	38	12	400	3	3	3¾	0	1	18	72
St. Clair Furnace..............St. Clair, Pa.............	1	1863	40	12¾	400	3½	6	2¾	0	2	22	72
Stanhope Furnace.............Pinegrove, Pa..........	1	1835	31	12		4½	4	2½	0	1	18	72
Total...	25											

No. 4.

THE SCHUYLKILL GROUP OF ANTHRACITE FURNACES.

NAME OF WORKS.	CAPACITY In tons of 2000 lbs. In 1850.	In 1857.	In 1865.	Production in 1864. In tons of 2000 lbs.	Weeks in Blast in 1864.	CONSUMED IN 1864. Ore. In tons of 2000 lbs.	Flux. In tons of 2000 lbs.	Anthracite Coal. In tons of 2000 lbs.	Capital Invested.
Wm. Penn Furnaces....	4,000	5,040	11,500	9,400	52	24,640	11,200	20,160	$150,000
" "		6,160			32				
Spring Mill Furnace.....	4,480	4,480	4,600	3,737	50				75,000
Merion Furnace..........	4,000	5,040	7,000	6,503	50	15,857	8,988	11,381	100,000
Plymouth Furnaces.....	3,750	4,900	11,000	6,194	52	14,436	7,620	12,310	300,000
" "	00	00				00	00	00	
Swede Furnaces..........	4,500	6,200	6,500	6,045	52	13,900	9,883	10,462	200,000
" "	00	6,200							
Lucinda Furnace..........	00	4,480	4,000	3,803	52	5,040	3,920	8,960	
Montgomery Furnace...	00	7,000	7,000	6,112	52	11,570	4,561	11,210	150,000
Phœnixville Furnaces..	4,600	5,000	6,500	13,613	52				
" "	4,600	5,000	6,500		52				
" "	5,600	6,000	11,500		00				
Monocacy Furnace.......	00	5,000							
Keystone Furnace........	00	5,000		5,732	52				
Reading Furnace.........	00	8,400		7,534	52				
Henry Clay Furnaces...	4,000	5,040	12,000	11,205	52	27,870	19,956	26,307	300,000
" "	00	6,160							
Robesonia Furnaces.....		4,000	4,010	2,750	42	17,715	5,360	14,646	300,000
" "	00	6,000	6,040	3,680	37				
Leesport Furnace.........	00	6,000		5,600	52				
Moselem Furnace.........		4,000							
Pioneer Furnace...........	2,500	4,600	5,000	4,596	52	9,106	4,189	8,254	100,000
St. Clair Furnace.........	00	00	6,000	5,800	52	12,000	5,824	11,200	
Stanhope Furnace.......		3,500	3,500	550¼	13				150,000

No. 5.

THE LOWER SUSQUEHANNA GROUP OF ANTHRACITE FURNACES.

NAMES OF WORKS AND POST OFFICE ADDRESS.	No.	FURNACES.			BLAST.				POWER 40 to 50 lbs. pres're.			
		Date of Erection.	Height in Feet.	Width of Bosh in Feet.	Heat of Blast. In Degrees.	Pressure. Square Inch.	No. of Tuyres.	Diame'r of Tuyres. Inches.	Water Wheels.	Steam Engines.	Diameter of Steam Cylinder. Inches.	Length of Stroke. Inches.
Stanhope Furnace............Pinegrove, Pa.........	1	1835	30	12	550	3½	4	2½	......	1	14	72
Harrisburg Furnace.........Harrisburg, Pa.......	1	1845	40	11	600	4	3	4	......	1	24	72
Paxton Furnace................ "	1	1855	43	15	500	4	6	2½	......	1	32	54
Middletown Furnaces.......Middletown, Pa......	1	1853	40	12½	600	5½	3	4	......	1	28	60
" " ...... "	2	1853	40	12½	600	5½	3	4	......	1	28	60
Cameron Furnace.............. "	1	1856	35	12½	500	5	3	3¾	......	1	24	60
Union Deposit Furnace.....Union Deposit, Pa...	1	1854	39	11	600	3½	3	3½	......	1	15	60
New Market Furnace........Anville, Pa............	1	1855	38	9	......	......	......	......	......	......	......	—
Lebanon Furnaces...........Lebanon, Pa..........	1	1846	35	12	420	4½	3	4	......	1	30	54
" " .... "	2	1847	35	14	420	4½	3	4	......	1	24	72
" " .... "	3	1856	40	10	......	......	......	......	......	1	30	72
Donaghmore Furnace...... "	1	1854	37½	13	500	3½	3	3½	......	1	30	72
Cornwall Furnaces...........Cornwall, Pa.	1	1850	38	12	500	5	3	3	......	1	30	72
" " .... "	2	1855	38	14	500	5	3	3	......	1	30	72
Marietta Furnaces...........Marietta, Pa............	1	1848	37	11	600	4	3	3½	......	1	18	45
" " .... "	2	1850	37	12	600	4	3	4	......	1	15	45
Chickies Furnace..............Chickies, Pa............	1	1845	37	11	600	3½	3	3½	......	1	20	45
Eagle Furnace..................Marietta, Pa............	1	1854	35	12	600	4½	3	3¾	......	1	20	45
Henry Clay Furnace.........Columbia, Pa...........	1	1845	38	10	600	3¾	3	3¾	......	1	20	48
St. Charles Furnace.......... "	1	1854	45	14	600	3½	3	5	......	1	30	72
Josephine Furnace............ "	1	1853	50	14	600	4¾	3	4¾	......	1	36	54
Isabella Furnace............... "	1	1844	40	10	600	4¾	3	5¾	......	1	20	72
Donegal Furnace.............. "	1	1847	35	12	600	4	3	4	......	1	20	45
Cordelia Furnace.............. "	1	1846	36	12	600	4	3	3¾	......	1	20	45
Conestoga Furnace............Lancaster, Pa..........	1	1846	38	11	600	3½	3	4½	......	1	20	45
Safe Harbor Furnace.........Safe Harbor, Pa......	1	1848	45	14	450	4	6	3½	......	1	36	72
Havre Furnace..................Havre-de-Grace, Md.	1	1844	33	9	400	3½	3	3½	......	1	18	45
" " .... "	2	1844	30	9	400	3½	3	3½	......	1	18	45
South Baltimore Furnace...Baltimore, Md........	1	1853	33	10	500	3	3	3½	......	1	22	45
Oregon Furnace................Cockeysville, Md.....	1	1845	36	11	400	3	3	3	......	1	26	60
Ashland Furnaces.............Ashland Station, Md.	1	1845	32	12	600	3½	3	3½	1	......	......	72
" " .... "	2	1853	32	12	600	3½	3	3½	......	1	28	60
Totals	32	......	......	......	......	......	97	......	1	30	......	—
Averages	......	......	37	12	540	4¾	3	3¾	......	......	24½	62

No. 6.

THE LOWER SUSQUEHANNA GROUP OF ANTHRACITE FURNACES.

NAME OF WORKS.	CAPACITY. Tons of 2,000 lbs. In 1850.	In 1857.	In 1865.	Production in 1864. Tons of 2,000 lbs.	Weeks in blast in 1864.	CONSUMED IN 1864. Ore. In tons of 2,000 lbs.	Flux. In tons of 2,000 lbs.	Anthracite Coal. In tons of 2,000 lbs.	Capital invested.
Stanhope Furnace........	3,000	3,500	3,500	550½	13	1,200	550	1,000	$150,000
Harrisburg Furnace.....	4,200	4,500	6,000	4,109	52	12,382	5,703	10,528	100,000
Paxton Furnace	....	6,500	6,700	6,399	52	13,500	6,500	13,000	150,000
Middletown Furnaces...	....	4,000	12,000	10,000	52	21,666	8,666	22,504	150,000
" "	....	4,000			40				
Cameron Furnace	....	5,500	7,261	6,693	52	15,513	6,978	12,718	150,000
Union Deposit Furnace.	....	3,500	5,000	1,000	15	2,250	1,000	2,000	100,000
New Market Furnace...	....	....	....	....	....	....	....	....	....
Lebanon Furnaces........	5,200	5,200	16,500	10,325	52	21,071	7,791	23,696	300,000
" "	5,000	5,000			44				
" "	....	3,000							
Donaghmore Furnace...	....	5,000	8,000	5,201	46	10,251	3,216	9,679	125,000
Cornwall Furnaces.......	5, 500	5,500	12,000	10,452	52	21,038	7,762	17,901	200,000
" "	....	5,500			52				
Marietta Furnaces........	4,200	4,900	5,800	10,756	52	25,100	10,756	20,000	200,000
" "	4,200	4,500	6,500		52				
Chickies Furnace.........	2,900	4,000	5,000	4,234	52	9,325	4,195	7,561	150,000
Eagle Furnace.............	....	5,000	5,600	4,485	50	10,557	5,439	9,987	135,000
Henry Clay Furnace....	3,200	4,000	4,500	3,330	49	8,325	3,825	7,100	125,000
St. Charles Furnace......	....	6,000	6,500	5,145	43	12,637	4,397	8,934	200,000
Josephine Furnace... ...	....	4,000	10,000	7,965	50	12,781	4,704	9,402	300,000
Isabella Furnace..........	....	6,000			30	5,822	2,246	4,374	
Donegal Furnace..........	4,200	5,500	6,500	5,531	52	12,662	4,938	9,621	150,000
Cordelia Furnace..........	2,400	3,600	5,000	2,112	26	4,947	1,883	3,984	150,000
Conestoga Furnace.......	3,000	4,450	4,500	3,332	36	8,000	3,000	6,000	60,000
Safe Harbor Furnace....	2,400	6,000	8,500	6,628	51	17,000	6,033	12,106	100,000
Havre Furnace............	4,000	4,000	4,000	1,142	17	3,140	1,000	2,000	100,000
" "	4,000	4,000	4,000	....	....	....	....	....	
South Baltimore Furn'e	....	....	....	....	....	....	....	....	....
Oregon Furnace..........	5,000	5,000	5,000	....	....	....	....	....	60,000
Ashland Furnace.........	5,000	5,000	12,500	9,236	44	22,595	9,467	14,791	150,000
" "	5,000	5,000			48				
Totals..................	72,400	141,650	170,861	118,615	1,174	271,762	10,065	228,886	3,305,000
Averages	4,024	4,721	5,695	4,394	43½	10,065	4,076	8,477	110,166

No. 7.

THE UPPER SUSQUEHANNA GROUP OF ANTHRACITE FURNACES.

NAME OF WORKS AND LOCATION.		No.	FURNACES.			BLAST.				POWER. 40 to 50 pounds pressure.			
			Date of Erection.	Height in Feet.	Width of Bosh. In Feet.	Heat of Blast. In Degrees.	Pressure, Square Inch.	No. of Tuyres.	Diame'r of Tuyres. Inches.	Water Wheels.	Steam Engines.	Diameter of Steam Cylinder. Inches.	Length of Stroke. Inches.
Juniata Furnace	Williamsburg, Pa.	1	1837	28	10	400	4	3	2¾	1	0	00	72
Duncannon Furnace	Duncannon, Pa.	1	1854	42	14	400	5	6	4	0	2	25 25	84 84
Glamorgan Furnace	Lewistown, Pa.	1	1853	40	11	600	3	3	3¾	0	1	22	48
Union Furnace	Winfield, Pa.	1	1854	40	15	550	4	3	3½	0	1	24	84
Chulasky Furnace	Chulasky, Pa.	1	1845	43	13	500	3	3	2½	0	1	24	72
Columbia Furnaces	Danville, Pa.	1	1839	50	12	700	4	4	3⅜	0	1	18	42
" "	"	2	1860	50½	14	700	4	6	3½	0	1	36	84
Penna. Iron Works	"	2	1839	35	17	550	3	6	4	0	1	24	72
" " "	"	3	1839	35	17	550	3	6	4	0	1	24	72
" " "	"	4	1846	35	14	550	3	4	4	0	1	24	72
Bloom Furnace	Bloomsburg, Pa.	1	1854	48	14	400	4	3	2¼	0	1	30	72
Irondale Furnaces	"	1	1844	36	12	400	2⅝	3	4	1	...	....	.....
" "	"	2	1844	36	14	400	2⅝	5	3¼	1	1	25	60
Henry Clay Furnace	Lightstreet, Pa.	1	1847	32	9	......	......	...	......	...	...	....	.....
Roaring Creek Furnace	Danville, Pa.	1	1840	30	9	......	......	...	......	...	...	....	.....
Hunlach's Creek Furnace	abandoned	1	1854	40	11	......	......	...	......	...	...	....	.....
Williamsburg "	Lightstreet, Pa.	1	1845	28	8	500	3	3	3	0	1	20	48
Lackawanna "	Scranton, Pa.	1	1848	50	18	600	6	6	3	0	1	54	120
" "	"	2	1848	50	18	600	6	6	3	0	1	54	120
" "	"	3	1853	50	19	600	6	6	3	0	1	58	120
" "	"	4	1855	50	20	600	6	6	3	0	1	58	120
Wyoming "	abandoned	1	1847	32	9	......	......	...	......	...	...	....	.....
Shamokin "	Shamokin, Pa.	1	1842	45	12	600	4½	3	3⅜	0	1	....	.....
Franklin "	Danville, Pa.	1	1846	32	9	......	......	...	......	...	...	....	.....
Williamsport "	Williamsport, Pa.	1	1855	38	13	500	4	4	3	0	1	24	60
Lycoming "	Ralston, Pa.	1	1854	50	16	500	4	6	3	0	1	51	120
Mill Hall "	Mill Hall, Pa.	1	1830	32	10	......	......	...	......	...	...	....	.....
Hope "	Near Lewistown, Pa.	1	1856	39	12	......	......	...	......	...	...	....	.....
Penn "	Catawissa, Pa.	1	1845	28	7	400	3	3	2	1	0	00	36
Totals		29											
Averages													

No. 8.

THE UPPER SUSQUEHANNA GROUP OF ANTHRACITE FURNACES.

NAME OF WORKS.	CAPACITY. In Tons of 2,000 lbs. In 1850.	In 1857.	In 1865.	Productions in 1864.	Weeks in Blast in 1864.	CONSUMED IN 1864. Ore. In tons of 2,000 lbs.	Flux. In tons of 2,000 lbs.	Anthracite Coal. In tons of 2,000 lbs.	Capital invested.
Juniata Furnace..........	00	2,000	2,000	1,500	36	5,000	2,800	3,000	$30,000
Duncannon Furnace.....	00	5,600	6,000	4,986	52	9,992	4,800	9,224	100,000
Glamorgan Furnace.....	00	4,500	4,500	990	16	3,028	1,757	2,455	150,000
Union Furnace............	00	5,040	6,000	5,756	52	18,055	9,936	12,920	125,000
Chulasky Furnace.......	4,000	5,040	6,000	3,162	47	14,450	5,589	9,236	125,000
Columbia Furnaces....... " "	3,000 00	4,000 00	55,000	9,167 4,590	52 52	32,697	17,865	21,540	523,130
Penna. Iron Works...... " " " ...... " " "	4,700 4,700 7,200	9,520 9,000 6,200	23,600	20,396	47 50 48	43,962	29,800	41,080	600,000
Bloom Furnace...........	00	6,800	8,000	7,398	52	24,376	11,843	14,160	150,000
Irondale Furnaces........ " "	11,500	5,600	13,100	12,672	52	35,871	18,340	24,342	400,000
Henry Clay Furnace.....	2,800	2,800	00	00	00	00	00	00	00
Roaring Creek Furnace.	2,300	2,800	00	00	00	00	00	00	00
Hunlach's Creek Fur....	00	3,400	00	00	00	00	00	00	00
Williamsburg..............	2,200	2,300	2,300	327	10	900	327	736	25,000
Lackawanna................ " .... " .... "	4,000 4,000 00 00	8,000 4,000 5,600 5,600	60,000	28,020	52 52 40 20	53,484	27,048	59,393	600,000
Wyoming....................	00	2,300	00	00	00	00	00	00	00
Shamokin....................	4,000	4,500	4,500	2,500	40	5,200	2,500	5,000	100,000
Franklin......................	2,300	2,300	00	00	00	00	00	00	00
Williamsport	00	3,000	3,000	800	20	1,750	800	1,650	100,000
Lycoming....................	00	9,000	9,000	2,700	28	8,100	2,700	5,400	200,000
Mill Hall	2,000	4,000	4,000	00	00	00	00	00	50,000
Hope	00	00	00	00	00	00	00	50	00
Penn Furnace...............	00	00	00	00	00	00	00	00	00
Totals......................				106,964					
Averages									

No. 9.

THE EASTERN GROUP OF ANTHRACITE FURNACES.

(Including Furnaces East and North of Pennsylvania, excepting the Cooper Furnaces at Phillipsburg, N. J., which belong to the Lehigh Group.

NAME OF WORKS, LOCATION, AND POST OFFICES.		WER.	
		Diameter of Steam Cylinder. Inches.	Length of Stroke. Inches
Boonton Furnace	Boonton, N. J.	0	84
Sterling Furnace	Sterling, N. Y.	30	72
Clove Furnace	Orange co., N. Y.	24	72
Manhattan Furnaces	Manhattanville, N. Y.	20	72
" "	" "	20	72
Peekskill Furnace	Peekskill, N. Y.	30	60
Verplanck Furnace	Verplanck, N. Y.		
Philip's Iron Works	Cold Spring, N. Y.	34	72
Po'keepsie Furnaces	Po'keepsie, N. Y.	24	72
" "	" "	36	72
Fallkill Furnaces	" "	40	84
" "	" "	40	84
Napanock Furnace	Napanock, N. Y.	0	72
Hudson Furnaces	Hudson, N. Y.	64	106
" "	" "	20	72
Columbia Furnace	" "	30	72
Fort Edward Furnace	Fort Edward, N. Y.	0	60
Siscoe Furnace	Westport, N. Y.	18	48
Port Henry Furnaces	Port Henry, N. Y.	0	72
" "	" "	34	72
" "	" "	40	84
Franklin Iron Works	Clinton, N. Y.	0	72
Buffalo Union Iron Works	Buffalo, N. Y.	36	84
" " "	" "	36	84
" " "	" "	42	84
Fletcher Furnace	" "	36	72
Cone Iron Works	W. Stockbridge, Mass	18	30
" "	" "	20	48
Taghonic Furnace	Housatonic, Mass.		
Sharon Station Furnace	Sharon Station, N. Y.		
Monitor Iron Works	Kent Station, Mass.	0	72
Total			

No. 10.

THE EASTERN GROUP OF ANTHRACITE FURNACES.

(Including Furnaces East and North of Pennsylvania, excepting the Cooper Furnaces at Phillipsburg, N. J., which belong to the Lehigh Group.)

NAME OF WORKS.	CAPACITY. In Tons of 2,000 lbs. In 1850.	In 1857.	In 1865.	Production in 1864.	Weeks in Blast in 1864.	CONSUMED IN 1864. Ore. In Tons of 2,000 lbs.	Flux. In Tons of 2,000 lbs.	Anthracite Coal. In tons of 2,000 lbs	Capital Invested.
Boonton Furnace.........	7,000	8,600	8,600	7,168	52	14,694	6,160	13,115	
Sterling Furnace..........	3,000	3,000	8,000	00	00	00	00	00	
Clove Furnace.............	00	9,000	9,000	4,824	28	13,488	2,760	12,713	
Manhattan Furnaces....	00								
" "	00								
Peekskill Furnace........	00	4,000	6,500	5,146	41	10,483	2,856	11,816	$150,000
Verplanck Furnace......	00	00	00	00	00	00	00	00	
Phillips' Iron Works...	00	00	6,500	4,013	38	7,900	2,900	8,000	
Po'keepsie Furnaces.....	6,000	8,000	8,000	15,499	52	27,148	8,848	30,520	
" "	00	8,000	8,000		52				
Fallkill Furnaces.........	00	00	9,000	15,414	52	28,352	9,457	31,146	
" "	00	00	9,000		44				
Napanock Furnace.......	3,600	3,000	3,000	00	00	00	00	00	
Hudson Furnaces	00	14,000	21,500	13,566	39	37,132	10,174	27,132	375,000
" "	00				39				
Columbia Furnace........	00	00	8,000	5,232	42	10,554	2,923	9,892	150,000
Fort Edward Furnace...	00	8,000	13,000	8,081	40	15,079	3,025	12,880	300,000
Siscoe Furnace............	4,000	5,000	5,000	2,906	30	4,826	1,012	4,000	100,000
Port Henry Furnaces...	6,000	6,000	6,000		29				
" " ...	00	10,000	10,000	17,259	52	30,112	7,840	33,606	400,000
" " ...	00	00	10,000		52				
Franklin Iron Works...	00	4,500	4,500	1,900	21	4,500	800	4,000	
Buffalo Union I'n Wk's.	00	00			06				
" "	00	00	26,441	18,623	52	31,945	10,182	35,703	
" "	00	00			52				
Fletcher Furnace..........	00	00	5,400	00	00	00	00	00	
Cone Iron Works.........	00	5,000	5,400	2,509	27	6,272	1,182	5,018	100,000
" "	00	00	6,000	00	00	00	00	00	
Taghonic Furnace........	3,000	3,000	3,000	00	00	00	00	00	50,000
Sharon Station Furnace	00	00	3,000	00	00	00	00	00	50,000
Monitor Iron Works.....	4,000	5,000	2,000	00	00	00	00	00	60,000

TABLE OF THE ROLLING MILLS MAKING RAILROAD RAILS IN THE UNITED STATES.

NAME OF WORKS.	OWNER IN 1864.	LOCATION AND POST OFFICE.	Date of Erection.	Number of Double Puddling Furnaces.	Number of Single Puddling Furnaces.	Number of Heating Furnaces.	Number of Trains. Rolls.	PRODUCTION. In Tons of 2000 lbs. 1863. New Rails.	1863. Re-Rolled.	1864. New Rails.	1864. Re-Rolled.	Present Capacity.
† Bay State Iron Works...	Bay State Iron Co.; Saml. Hooper, *Pres.* J. H. Reed, *Treas.*; R. Crooker, *Supt.*	Boston, Mass...............	1847	16	00	12	4	10,776	7,527	8,739	9,362	22,000
† Washburn Rolling Mill..	Washburn Iron Co......	Worcester, Mass	1857	3	2	11	2	00	15,294	00	12,211	16,000
† Rensselaer Rolling Mill..	Rensselaer Iron Co.; J. A. Griswold, *Agent*, (Erastus Corning, John F. Winslow, John A. Griswold.)	Troy, New York............	1853	00	14	12	5	2,714	16,707	2,181	17,205	20,000
† Langdon Rolling Mill....	Langdon R. M. Co.; J. R. Lawrence, *Treas.*	Spuyten Duyvel............. West Chester co., N. Y.	1863	5	9	9	2	00	00	5,152	2,000	24,000
* Delano Iron Works......	Syracuse R. M. Co.; H. Delano, *Pres.*, C. W. Allis, *Sec and Treas.*	Syracuse, New York.........	1865	00	6	4	2	00	00	00	00	6,000
* Elmira Rolling Mill......	Elmira R. M. Co...................	Elmira, New York...........	1860	4	0	6	3	00	12,977	00	13,332	20,000
† Union Iron Works	Buffalo Union Iron Co.; John Griffin, *Genl. Supt.*,	Buffalo, New York..........	1862	14	00	15	5	541	6,081	3,723	13,840	28,000
† Trenton Iron Works.....	Trenton Iron Co.; E. Cooper, *Pres.*, E. F. Bedell, *Sec.*, J. Hall, *Tr.*, C. Hewitt, *Man.*	Trenton, New Jersey........	1845	10	10	17	9	5,635	00	2,577	9,110	14,000
† Allentown Rolling Mill..	Allentown R. M. Co.; Chas. Cabot, *Pres.*, Geo. B. Newton, *Sec. and Tr.*; L. H. Gross, *Supt.*	Allentown, Pennsylvania.....	1860	15	00	8	5	8,564	00	8,392	00	15,000
† Bethlehem Rolling Mill..	Bethlehem Iron Co.; Alfred Hunt, *Pres.*, John Fritz, *Supt.*	Bethlehem.................. Northampton co., Pa.	1863	14	00	6	2	2,400	00	11,584	00	18,000
† Palo Alto Rolling Mill...	Palo Alto Iron Co.; B. Haywood, *Pres.*	Pottsville, Schuylkill co., Pa.	1855	4	5	5	2	6,000	00	5,727	00	12,000
† Pottsville Rolling Mill...	Atkins & Bro......................	Pottsville, Schuylkill co., Pa.	1852	7	00	4	2	00	00	2,305	161	7,000
† Phœnix Rolling Mill.....	Phœnix Iron Co.; David Reeves, *Pres.*, Samuel J. Reeves, *Vice Pres.*	Phœnixville, Chester co., Pa.	1846	16	11	24	8	3,789	5,121	2,868	5,318	30,000
† Safe Harbor Rolling Mill.	Phœnix Iron Co....................	Safe Harbor, Lanc'st'r co., Pa.	1848	17	00	6	2	00	00	00	00	14,000
† Columbia Rolling Mills..	Maltby and Case; D. Richards, *Man.*, (C. S. Maltby and W. G. Case.)	Columbia, Lancaster co., Pa.	1854	3	6	5	2	4,733	1,352	4,817	1,888	15,000
† Lochiel Rolling Mills....	Lochiel Iron Co.; Henry Thomas, *Pres.*, W. E. C. Coxe, *Supt.*	Harrisburg, Dauphin co., Pa.	1865	30	00	14	5	00	00	00	00	30,000
† Pennsylvania Iron Works	Waterman & Beaver................	Danville, Montour co., Pa....	1846	17	31	14	5	18,708	3,641	24,446	4,858	34,000

† Rough and Ready Iron Works	Hancock & Foley; Benj. C. Welch, *Ag't*, (W. Hancock & John B. Foley.)	Danville, Montour co., Pa	1847	00	15	6	4	6,500	8,408	6,090	4,161	12,000
† Lackawanna Rolling Mill	Lackawanna Iron and Coal Co.; J. H. Scranton, *Pres.*, D. S. Dodge, *Treas.*, E C. Lynde, *Sec.*, C. F. Mattis, *Supt.*	Scranton, Luzerne co., Pa	1847	00	76	15	6	26,488	00	20,776	00	35,000
* Cambria Rolling Mill	Cambria Iron Co.; Chas. S. Wood, *Pres.*, E. Y. Townsend, *Vice Pres.*, D. J. Morrell, *Genl. Supt.*	Johnstown, Cambria co., Pa.. Philadelphia Office, No. 400 Chestnut st.	1853	30	00	22	6	24,324	14,450	31,915	12,126	56,000
* Brady's Bend Rolling Mill	Brady's Bend Iron Co.; W. B. Ogden, *Pres.*	Brady's Bend, Armstrong co., Pennsylvania.	1841	00	25	10	2	7,872	00	10,889	680	22,000
* Superior Iron Works	Superior Iron Co.; Jas. I. Bennett, *Pres.*, John Scott, *Treas.*	Pittsburg, Alleghany co., Pa..	1865	00	26	9	2	00	00	00	00	18,000
* Mount Savage Rolling Mills	Consolidation Coal Co.; A. J. Center, *Pres.*, Chas. P. Manning, *Supt.*	Mount Savage, Alleghany co. Maryland.	1840	00	10	7	2	00	6,000	3,248	2,240	20,000
* Washington Rolling Mills	Drakely & Co.; D. Darragh, *Man*	Wheeling, Ohio co., West Va.	1854	00	13	5	5	00	1,993	00	844	6,000
* Crescent Rolling Mills	G. P. Whitaker & Sons	Wheeling, Ohio co., West Va.	1853	11	2	8	1	00	4,000	00	00	12,000
* Lake Shore Rolling Mill. } * Newburg Rolling Mill.. }	Cleveland R. M. Co.; A. B. Stone, *Pres.*, D. O. Cole, *Sec.*, H. Chisholm, *Gen. Sup.*	Cleveland, Ohio; Cleveland, Ohio	1852; 1857	13	1	16	2	00	15,046	2,128	18,173	26,000
* Cincinnati Rolling Mills	Cincinnati Railway Iron Co.; L. Worthington, *Pres.*	Cincinnati, Ohio	1865	00	6	6	2	00	00	00	00	10,000
* Covington Rolling Mill	Covington R. M. Co.; Buchanan & Mansor, *Lessees.*	Covington, Kentucky	1854	00	7	7	2	00	3,168	00	4,441	16,000
* Louisville Rolling Mill	Louisville R. M. Co.; T. C. Coleman, *Pres.*	Louisville, Kentucky	1864	00	13	6	2	00	00	00	00	10,000
* Indianapolis Rolling Mill	Indianapolis R. M. Co.; J. M. Lord, *Pres.*, C. B. Parkman, *Sec.*	Indianapolis, Indiana	1857	3	0	13	2	00	10,011	00	12,773	30,000
* Chicago Rolling Mill	Chicago R. M. Co.; Stephen Clement, *Pres.*, E. B. Ward, *Treas.*, O. W. Potter, *Sec. and Sup.*	Chicago, Illinois	1857	00	2	17	10	00	9,813	00	14,560	36,000
* Union Rolling Mill	Union R. M. Co.; A. B. Stone, *Pres.*, E. K. Rogers, *Vice Pres.*, Wm. Chisholm, *Sec. and Sup.*	Chicago, Illinois	1863	2	12	7	4	00	4,480	00	12,320	14,000
* East St. Louis Rolling Mill	East St. Louis R. M. Co.; Gerard B. Allen, *Pres.*, A. Meir, *Vice Pres. & Treas.*	East St. Louis, Illinois	1865					00	00	00	00	30,000
* Wyandotte Rolling Mill	Wyandotte R. M. Co.; E. B. Ward, *Pres.*, W. H. Zabriskie, *Sec.*	Detroit, Michigan	1855	0	8	15	7	00	5,600	00	5,600	20,000
* Laclede Rolling Mill	Chouteau, Harrison & Valle	St. Louis, Missouri	1856	2	12	7	4	00	00	00	00	10,000
* Chattanooga Rolling Mill.	U. S. Government	Chattanooga, Tennessee	1863	0	0	6	2	00	00	00	00	9,000
* Atlanta Rolling Mill		Atlanta, Georgia	1859	0	0	6	2	00	00	00	00	9,000
* Canton Rail Mill	Abbott Iron Co.; Horace Abbott, *Pres.*	Baltimore, Maryland	1865	4	0	6	2	00	00	00	00	9,000
Total....								129,099	146,669	158,166	177,203	735,000

* Anthracite coal used. † Bituminous coal used.

MANUFACTURERS OF STEEL.

The following is, as nearly as can be ascertained, a List of all the Parties engaged in the Manufacture of Steel in the United States. It has been revised by some of the Principal Steel Makers in the Country.

Naylor & Co.,	Boston, Mass.,	Blister and Spring Steel.
Plimpton Iron & Steel M. Co.,	Walpole, Mass.,	
Boston Steele & Iron Co.,	Boston, Mass.,	Tool, file, railroad Cast Steel.
Whipple File Co.,	Ballard Vale, Mass.	
Old Colony Iron Co.,	Taunton, Mass.,	
Collins & Co.,	Collinsville, Conn.,	Cast Steel.
Joel Fairest & Co.,	Windsor Locks, Ct.	
Sweet, Barnes & Co.,	Syracuse, N. Y.,	Refined Cemented Steel.
E. W. Madden & Co.,	Middletown, N. Y.,	Cast Steel for Saws.
Kelley, Demilt & Co.,	New York, N. Y.,	Cast Steel.
Mulliken & Co.,	New York, N. Y.,	Cast Steel.
Montauk Iron & Steel Co.,	Mott Haven, N. Y.,	Cast Steel direct from ores.
Weed, Beckner & Co.,	Cohoes, N. Y.	
New York Steel Co.,	New York, N. Y.,	Cast Steel.
Winslow, Griswold & Holley,	Troy, N. Y.,	Bessemer Steel.
S. A. Millard,	Clayville, N. Y.,	Cast Steel.
Walter Gregory & Co.,	Jersey City, N. J.,	Cast Steel.
J. R. Thompson & Co.,	Jersey City, N. J.,	Cast Steel.
Prentice, Atha & Co.,	Newark, N. J.,	Cast Steel.
Trenton Iron Co,	Trenton, N. J.,	Puddled and Cast Steel.
Horner & Ludlam,	Pompton, N. J.,	Cast Steel.
Hussey, Wells & Co.,	Pittsburg, Pa.,	Cast and Shear Steel.
Jones, Boyd & Co.,	Pittsburg, Pa.,	Cast and Blister Steel.
Park, Bro. & Co.,	Pittsburg, Pa.,	Cast Spring, Plow, &c.
Singer, Nimick & Co.,	Pittsburg, Pa.,	Cast, Spring, Plow and Plate Steel.
Hailman, Rahm & Co.,	Pittsburg, Pa.,	Plow and Spring Steel.
Brown & Co.,	Pittsburg, Pa.,	Cast and Common Plow Steel.
Reiter & Co.,	Alleghany City, Pa.,	Cast, Blister, and Spring Steel.
William Bancroft,	Philadelphia, Pa.,	Hammered Cast Steel.
Henry Disston,	Philadelphia, Pa.,	Cast, Saw, Steel, &c.
William Rowland & Co.,	Philadelphia, Pa.,	Cast, Saw, Spring, &c.
Bringhurst & Co.,	Philadelphia, Pa.,	Cast, Saw, Spring, &c.
James Rowland & Co,	Philadelphia, Pa.,	Cast, Spring, Plow, &c.
Verree & Mitchell,	Philadelphia, Pa.,	Cast, Spring, Plow, &c.
W. Baldwin & Co.,	Philadelphia, Pa.,	Cast Steel, Hammered, &c.
Pneumatic Steel Co.,	Wyandotte, Mich.,	Pneumatic Steel.
Chicago Steel Works,	Chicago, Ill.,	Cast Steel.

IRON AND STEEL MANUFACTURERS OF THE UNITED STATES IN 1864.

Character of Manufactures.	Tons of 2000 lbs.	Internal Revenue Tax.	Rate of Tax.
Tons of new Railroad Iron rolled	117,225	$175,838	$1 50 per ton
Tons of re-rolled Railroad Iron	158,967	119,225	75 "
Hoop and Sheet-Iron above 18 wire gauge	77,670	116,596	1 50 "
Band, Hoop and Sheet-iron bel. 18 wire gauge	19,136	39,472	2 00 "
Iron Plate not less than ⅛ in. thickness	52,991	79,487	1 50 "
Iron Plate less than ⅛ in. thickness	3,524	7,048	2 00 "
Iron advanced beyond blooms and not beyond bars	197,297	268,945	1 50 "
Cast-Iron for bridge building, &c.	33,483	33,483	1 00 "
Other Castings exceeding 10 lbs. in weight	139,502	209,253	1 50 "
Cut-Nails and Spikes	92,250	184,500	2 00 "
Rivets, R.R. Chairs, Nuts, Bolts, Horse-shoes, &c.	17,389	34,778	2 00 "
do. from Iron on which a duty has been paid	17,902	8,951	50 "
Other articles made from Iron on which a duty of $1.50 has been paid	21,973	10,986	50 "
Cast-Iron Hollow-ware	15,544	23,316	1 50 "
Manufactures not otherwise provided for, value $63,035,390		1,891,016	3 per cent on assess'd value
Marine Engines, value $2,181,140		65,434	" "
Wood Screws	2,098	62,943	1½ cts. per lb.
Stoves	66,781	100,171	$1 50 per ton
Steel, Ingots, Bars, Sheets and Wire, valued at 7 cts. per lb., above ¼ inch in thickness	1,345	5,380	4 00 "
do. valued above 7 cts. and not above 11 cts. per lb.	4,395	35,162	8 00 "
do. valued above 11 cts. per lb., value $9,979	5,122	51,225	10 00 "
Manufactures of Steel not otherwise provided for		299,337	3 per cent on assess'd value
		$3,822,546	

STATISTICS OF IRON.

PRODUCTION OF PIG-IRON IN THE UNITED STATES.

	Tons.		Tons.
1810	54,000	1845	486,000
1828	130,000	1846	765,000
1829	142,000	1847	800,000
1830	165,000	1849	800,000
1831	191,000	1850	600,000
1832	200,000	1855	500,000
1840	347,000	1860	884,474
1842	215,000	1864	*1,200,000

* Of 2000 pounds to the ton.

PRODUCTION OF ANTHRACITE PIG-IRON IN THE UNITED STATES.

Furnaces.	No. of Furnaces.	No. of Furnaces in Blast 1865.	Capacity in 1856.	Production in 1864.	No. Tons of Coal used.	No. Tons of Ore used.	Ore & Coal used per ton of Iron produced.	
							Ore.	Coal.
Lehigh Group,............	30	22	267,116	214,093	459.051	486.105	$2\frac{1}{3}$	$2\frac{1}{2}$
Schuylkill Group,.........	24	20	130,000	112,806	227,000	259,000	$2\frac{3}{10}$	2
Lower Susquehanna Group,	32	22	170,861	118,615	228,886	271,762	$2\frac{1}{3}$	2
Upper Susquehanna Group,	29	16	167,500	108.664	213,477	261,015	$2\frac{2}{5}$	2
Eastern Group,...........	31	10	201,841	130,140	256,147	242,485	$1\frac{9}{10}$	2
	146	90	937,318	684,519	1,384,561	1,520,367		

RAILROADS IN THE UNITED STATES.—YEARLY INCREASE IN MILES.

YEAR.	Miles of Railroads in operation.	Yearly Increase in miles.	Importation of Rails. Tons (2240 lbs.)	Reported Make of Amer'n Mills. Tons (2240 lbs.)	Reported Capacity Tons (2240 lbs.)
1838	1,843				
1839	1,920	77			
1840	2,167	247	29,092		
1841	3,319	1,152	23,253		
1842	3,877	558	24.970		
1843	4,174	297	9,655		
1844	4,311	137	15,577		
1845	4,511	200	21,812		
1846	4,870	359	5,897		
1847	5,336	466	13,537	40,966	
1848	5,682	346	29,489		
1849	6,350	668	69,163	18,973	65,000
1850	7,355	1,005	142,037	15,000	
1851	9,090	1,735	188,626		
1852	11,631	2,541	245,626		
1853	13,213	1,582	298,995	105,000	
1854	18,265	5,052	282,867	121,000	
1855	21,128	2,862	127,516	134,000	
1856	24,476	3,348	155,496	142,555	
1857	26,210	1,734	179,305		
1858	27,158	948	75,745		
1859	29,213	2,055	69,965		
1860	31,185	1,972	122,174		
1861	31,800	615	74,496		
1862	32,471	671	8,611		
1863	33,860	1,389	17,088		
1864	35,000	1,140	105,854	283,560	68[illegible]

AMERICAN RAILROADS.

Year.	Miles in use.	Increase in Miles.	Rails Imported. Tons.	American Rails. Tons.	Total. Tons (2240 lbs.)
1828	3	3			
1840	2,167	2,164	108,350		108,350
1845	4,511	2,344	124,360		124,360
1850	7,355	2,844	260,123	150,000	410,123
1855	21,128	13,773	1,143,630	550,000	1,693,630
1860	31,185	10,057	602,686	750,000	1,352,686
Total,	31,185		2,239,149	1,450,000	3,689,149

Average time down for the whole number of miles................. $8\frac{1}{8}$ years

Average quantities of Foreign and American Rails laid per mile of Track—Foreign .... $71\frac{3}{16}$ tons per mile.

American.............................. $41\frac{1}{2}$ " "

Together.............................. $118\frac{3}{16}$ " "

APPROPRIATION OF RAILS USED.

In laying track from 1828 to 1845....	4,511 miles at	$51\frac{6}{16}$ tons per mile,	232,710 tons.		
In laying track from 1845 to 1860....	26,674 " "	86 " "	2,293,964 "		
	31,185 Average,	81 " "	2,526,674 "	68.49	per cent.
For renewing track, being the balance not used in laying track..........	"	$37\frac{3}{16}$ " "	1,162,475 "	31.51	" "
Total quantity for laying and renewing track..............		$118\frac{3}{16}$ "	3,689,149 "	100.00	

The renewal of track is equal to 46 per cent. of the quantity used in laying track. Dividing 46 per cent by eight and one-eighth years, the average time down of 31,185 miles, we have 5 2-3 per cent. as the average annual wear. Again dividing 100 per cent. by five and two-thirds per cent., gives seventeen and two-thirds years as the average wear of the rails.

TOTAL PRODUCTION OF PIG-IRON IN THE UNITED STATES, 1864.

	Tons.
Massachusetts,	2,509
New York,	120,463
New Jersey,	29,578
Pennsylvania,	521,391
Maryland,	10,037
Anthracite Iron,	684,319
Bituminous and Coke Iron,	210,108
Charcoal Iron,	255,486
Charcoal Iron, Southern States, (estimated)	50,000
	1,199,913

The following tables are from Fairbairn's Iron Manufacture:

Comparative table of the iron production of 1820 *and* 1827.

	1820. Tons.	Furnace.	1827. Tons.
North Wales	150,000	12	24,000
South Wales		90	272,000
Shropshire	180,000	31	78,000
Staffordshire		95	216,000
Yorkshire	50,000	24	43,000
Derbyshire		14	20,500
Scotland	20,000	18	36,000
	400,000	284	690,500

Total product of pig-iron during 1857.

England,	Northumberland	63,250
"	Durham	284,500
"	Yorkshire	296,83[illegible]
"	Lancashire	1,233
"	Cumberland	30,515
"	Derbyshire	112,1[illegible]
"	Sharpshire	117,141
"	North Staffordshire	134,057
"	South Staffordshire and Worcestershire	657,2[illegible]
"	Northamptonshire	11,5[illegible]
"	Gloucestershire	23,[illegible]
"	Somersetshire	[illegible]
Wales,	North	37,049
"	South. Anthracite districts	63,440
"	South. Bituminous districts	907,2[illegible]
Scotland,		918,[illegible]
Ireland,		1,[illegible]
		3,659,447

* QUANTITIES AND VALUE OF COAL AND IRON PRODUCED IN THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

[† *Estimated value at the place of production.*]

Blast-furnaces in operation in 1857.

England	333	blast-furnaces.
Wales	170	" "
Scotland	124	" "
Ireland	1	" "
	628	

Year.	Coal.—Tons.	Value.—£.	Pig-iron.—Tons.	Value.—£
1854	64,661,401	16,165,350	3,069,838	7,674,5[illegible]
1855	61,453,079	16,113,267	3,218,154	8,045,[illegible]
1856	66,645,450	16,663,862	3,586,377	8,963,942
1857	65,394,707	16,348,676	3,659,447	9,148,[illegible]
1858	65,008,649	16,252,162	3,456,064	8,640,[illegible]
1859	71,979,765	17,994,941	3,712,904	9,2[illegible]
1860	80,042,698	20,010,674	3,826,752	9,566,[illegible]
1861	83,635,214	20,908,803	3,712,390	9,2[illegible],975
1862	81,638,338	20,409,584	3,943,469	9,8[illegible]
1863	86,292,215	21,573,053	4,510,040	11,275,[illegible]

* The values seem to be arbitrary—they are invariably for every year five shillings per ton for coal, and two pounds ten shillings per ton for pig-iron. I take these items from the "Statistical Abstract for the United Kingdom," published by Parliament.

† Dr. Wm. Elder, Treasury Department, Washington.

PRODUCTIONS OF PIG-IRON IN FRANCE.

Year.	Tons.	Year.	Tons.
1855	850,000	1860	860,500
1856	920,000	1861	1,040,000
1857	1,000,000	1862	1,052,000
1858	875,000	1863	1,137,000
1859	858,000	1864	1,217,000

WROUGHT-IRON PRODUCTIONS OF FRANCE.*

Year.	Tons.	Year.	Tons.
1855	557,000	1860	580.000
1856	569,000	1861	570,000
1857	557,000	1862	670,000
1858	530,000	1863	791,000
1859	522,000	1864	821,000

TOTAL PRODUCTION OF PIG-IRON.

		Tons.
Great Britain	1863	4,510,040
United States	1864	1,200,000
France	1864	1,217,000
Prussia	1854	300.000
Austria	"	250,000
Belgium	"	200,000
Russia	"	200,000
Sweden	"	150,000
German States	"	100,000
Other Countries	"	300,000
		8,376,913

PRODUCTION OF STEEL.†

		Tons.
Great Britain	1865	200,000
United States	1864	18,000
France	1864	30,000
Prussia	1864	50,000
Austria	1860	15.000

NOTE.—There were erected, and in course of erection, sixty converting vessels in England during 1865, each capable of producing from three to ten tons of steel at a charge, or 6,000 tons per week, when in full operation, by the Bessemer process. One manufacturer, F. Krupp, in Essen, Prussia, turns out 50,000 of steel annually, by the Pneumatic mode.

* From Ryland's Iron Trade Circular.

† The Pneumatic mode of manufacturing steel is now making quite a revolution in the amount of its production, in all steel-producing countries. The British production is estimated.

SECTION II.
STATISTICS OF COAL.

ANTHRACITE COAL TRADE OF THE UNITED STATES.

The supply sent to market in 1865 was 9,488,396 tons, against 9,998,046 tons in 1864, showing a loss of 509,650 tons in 1865. The stoppage of iron works, manufactories, and the general stagnation of business that took place after the collapse of the great rebellion, caused a falling off in the supply of coal in a period of four months, of about 1,200,000 tons. The resumption of business, which commenced the latter part of September, and which still continues, soon demanded an increase over the supply of 1864, so that the loss of 1,200,000 tons was reduced by the close of the shipping season to 509,650 tons.

The importation of Foreign Bituminous Coal shows an increase of 174,416 tons over 1864, and the Cumberland trade has also increased largely over last year.

The whole quantity from the Semi-Anthracite and Bituminous Regions embraced in our table, sent to market in 1865, including the Imported Coal, sums up as follows:

	Tons.
In 1865	2,068,538
In 1864	1,949,432
Increase in 1865	319,106
Less loss in Anthracite	509,650
Total decrease in 1865	190,544

	1864. Tons.	1865. Tons.	Increase. Tons.	Decrease. Tons.
SCHUYLKILL REGION.				
By Reading Railroad	2,763,374	2,813,176	49,802	
By Schuylkill Canal	1,000,500	1,022,740	22,240	
From Pinegrove	24,534	18,485		6,040
By Mahanoy and Lehigh	132,808	218,378	85,570	
	3,921,216	4,072,779	157,612	6,049
Less Lehigh and Shamokin and Lackawanna	272,153	336,977	64,824	
	3,649,063	3,735,802	92,788	
		3,649,063	6,049	
Increase in 1865		86,739	86,739	
LEHIGH REGION.				
By Lehigh Valley Railroad	1,295,419	1,402,277	106,858	
By Lehigh Canal	758,087	888,784	130,697	
McCalley's Mount	1,787	546		1.241
By Little Schuylkill R. R.	8,690			8,690
	2,063,983	2,291,607	237,555	9,931
Less Wyoming Coal	9,314	250,694	241,380	
	2,054,669	2,040,913	3,825	
	2,040,913		9,931	
Decrease in 1865	13,756		13,756	

	1864. Tons.	1865. Tons.	Increase. Tons.	Decrease. Tons.
WYOMING REGION.				
Wyoming Canal, South....	536,088	329,506		206,582
North Branch Canal, North	94,054	28,957		66,097
Pennsylvania Coal Co.....	759,544	577,482		182,062
Scranton, North..........	338,729	264,293		74,436
" South..........	963,728	742,781		220,947
Delaware and Hudson Co..	852,136	759,570		92.566
Lackawanna and Bloom, S.	407,243	301,236		105,007
By Lehigh..............	9,314	250,694	241,380	
	3,960,836	3,254,519	241,380	947,697
	3,254,519			241,380
Decrease in 1865..........	706,317			706,317
SHAMOKIN REGION.........	333,478	457,162	123,684	
		333,478		
Increase in 1865...........		123,684		
Total Anthracite.........	9,998,046	9,488,396		
	9,468,396			
Total decrease in 1865.....	509,650			
Semi-Anthracite.				
Franklin Coal Co., S. M...	61,952	75,495	13,543	
" " " L. V....	68,021	61,405		6,616
Trevorton...............	56,501	27,095		29,406
Broad Top...............	386,645	315,996		70,649
	573,119	479,991	13,543	106,671
Bituminous.				
Cumberland Coal..........	665,605	903,495	237,890	
Imported—foreign........	510,708	685,052	174,344	
	1,749,432	2,068,538	725,777	106,671
Add Anthracite..........	9,998,046	9,488,396	106,671	
Total tons...............	11,747,478	11,556,934	319,106	
	11,556,934		509,650	
Total decrease...........	190,544		190,544	

The above amount of Anthracite Coal was mined from the several regions, as stated below in 1865:

	Tons.
Schuylkill Region..............................	1,912,147
Mahanoy "	1,823,655
Lehigh "	2,040,913
Wyoming "	3,254,519
Shamokin "	457,162
	9,488,396

The following is the loss and gain in 1865 from each Region:

	Loss. Tons.		Gain. Tons.
Schuylkill	......	......	86,739
Lehigh	13,756	......	......
Wyoming	706,317	......	......
Shamokin	......	......	123,684
	720,073	......	210,423
	210,423		
Total loss	509,650		

RÉSUMÉ.

Since the commencement of the trade in 1820, the different Regions have furnished the following quantities:

	Tons.
Schuylkill Region	60,422,057
Lehigh "	28,656,599
Wyoming and Lackawanna Region	42,050,008
Shamokin Region	2,992,885
Total Anthracite	134,121,549

From 1820, the commencement of the trade, up to 1866, the supply sent to market for forty-six years was as follows:

	Tons.
1820 to 1830	359.190
1830 to 1840	6,261,197
1840 to 1850	19,373,429
1850 to 1860	56,954,864
1860 to 1866 (six years)	52.172.869
Total Anthracite	134,121,549

According to the above statement, the annual increase was as follows:

From 1830 to 1840 was about	164	per cent.
From 1840 to 1850 "	21	"
From 1850 to 1860 "	19½	"
From 1860 to 1866 "	8½	"

The supply of Schuylkill Coal, amounting to 79,973 tons sent to market in 1829, which was an increase of 32,689 tons over the supply of 1828, broke up every Coal operator engaged in the business.

The following is the quantity of Coal sent to market by each company and firm in 1865, from the Schuylkill and Mahanoy Regions:

Names.	No. Cols.	Tons.
Mammoth Vein Con. Coal Co.	7	177,485
New York & Schuylkill Coal Co.	6	172,558
Wolf Creek Diamond Coal Co.	2	96,244
Locust Dale Coal Co.	1	74,327
George S. Repplier & Brother	1	38,762
Repplier & Moodie	1	86,508
Bast & Pearson	1	89,087
Do. Shamokin Coal Co	1	21,715
Miller, Graeff & Co	2	108,961
St. Nicholas Coal Co	1	90,818
Union Coal Co	2	87,337
A. C. Miller & Co	2	86,818
Preston Coal & Imp. Co.	3	86,577
Robert Gorrell & Co	1	86,311
11 Firms	32	1,303,508
Henry Heil	1	76,900
Wm. Kear & Co.	2	76,571
G. W. Johns & Brother	1	74,745
Greenwood Coal Co.	1	71,369
J. M. Freck & Co.	1	68,438
Conner & Patterson	1	47,156
Conner & Co	1	18,376
Swatara Falls Co	2	62,630
Bancroft, Lewis & Co.	1	62,087
C. Garretson	2	61,149
Star Coal Co	3	60,310
Glenville Coal Co	1	58,945
McNeal Coal & Iron Co	1	58,119
Black Diamond Coal & Iron Co.	2	55,402
George W. Cole	2	52,894
25 Firms	55	2,208,599
Little Schuylkill Co	5	48,389
Wiggan & Treibles	1	44,952
William Hindson	1	44,190
Althouse & Focht	1	40,870
Hill & Harris	1	40,144
George W. Snyder	1	39,978
Phœnix Park Coal Co.	2	39,854
Suffolk Coal Co.	2	39,083
J. & E. Silliman	1	38,593
St. Clair Coal Co	1	37,844
Glendon Coal Co	1	37,619
Charter Oak Coal Co.	1	37,640
Girard Mutual Coal Co.	1	36,900
John Anderson & Co	1	36,332
Alter & Focht	1	35,348
Gilberton Coal Co.	1	35,258
J. & O. O. Bowman	1	34,258
Pine Knot Coal Co.	1	34,254
Manchester Coal Co.	1	32,920
Pottsville Mining & Manuf. Co.	2	31,811
Eagle Hill Shaft Coal Co.	1	30,375
Gross, Clarke & Co.	1	28,829
Rathburn, Stearns & Co.	1	28,427
Knickerbocker Coal Co.	1	27,602
Hartford Associated Coal Co.	1	26,918
Glen Carbon Coal Co.	1	25,563
Eckert & Co.	1	25,213
New Phila. Mining Co.	2	24,565
Continental Coal Co.	1	23,878
Duncan Coal Co.	1	23,858
J. Seitzinger & Co.	1	22,431
Moss, Wood & Co.	1	21,757
B. Hammett	1	21,603
Wm. Wadleigh, agent	1	20,700
Schall & Donahoe	1	17,957
Goodman Dolben	1	17,673
Spring Hill Coal Co.	1	16,383
Mahanoy Coal Co.	1	16,154
H. Guiterman & Co.	1	16,074
Charles Sailor, agent	1	14,083
George Brown	1	13,872
East Mahanoy Coal Co.	1	13,683
George Ormrod	1	13,618
Black Heath Coal Co.	1	12,802
Gilfillan & Lynch	1	12,617
Coal Run Coal Co.	1	12,386
Broad Mountain Coal Co (new).	1	11,366
Winlach & Co.	2	10,591
Boston & Mahanoy Coal Co.	1	10,215
J. Lippincott & Co. now R. C. Hill,	1	9,993
S. E. Griscom & Co (new)	1	9,121
Belmont Coal & Mining Co.	1	8,913
J. A. Dutter & Co. (new)	1	8,106
L. L. Ellsworth	1	7,592
Norwegian Coal Co.	1	7,407
Mt. Carbon Coal Co.	1	7,068
New Haven Coal Co.	1	6,680
Buck & Collins	1	6,585
Feeder Dam Coal Co.	1	6,118
Wm. H. Sheafer	1	5,973
Wm. N. Taylor & Co.	1	5,797
Saml. Ratcliff	1	5,640
Lucas, Denning & Co. (new)	1	5,414
William Dovey	1	5,128
Consumers' Mutual Coal Co. (failed)	1	4,877
Kaska Wm. Coal Co.	1	4,266
Stroh Imp. Co. (new)	1	4,251
Lee, Grant & Co. (new)	1	4,168
Lore, Hine & Co. (new)	1	3,991
Salem Coal Co. (new)	1	3,525
B. D. Beddall (new)	1	3,204
Lorberry Coal Co. (new)	1	2,810
Peoples' Mutual Coal Co. (new)	1	2,288
J. B. Reber & Co. (new)	1	2,185
Red Mountain Coal Co.	1	1,710
James Coddington	1	1,661
Wm. Spencer, agent	1	1,407
Bauman & Kurtz	1	1,320
A. Brittain	1	968
Mt. Ætna Coal Co. (new)	1	929
John Wright	1	909
Silas Ball	1	761
East Mount Laffe Coal Co.	1	678
House Keepers' Coal Co. (new).	1	660
T. F. Patterson & Co. (new)	1	582
Sundry Shippers, Screenings, &c.		14,644
109 Shippers	146	3,735,802

It will be observed that 25 firms, with 55 collieries, mined and shipped nearly two-thirds of the coal sent to market in 1865.

MAHANOY COAL TRADE FOR 1865.

The following is the quantity of coal sent from the Mahanoy Region, by the different operators:

	Cols.	Tons.
Mammoth Vein Con. Coal Co	4	113,209
St. Nicholas Coal Co	1	90,818
Bast & Pearson	1	89,087
Union Coal Co	2	87,337
Repplier & Moodie	1	86,508
Preston Coal & Imp. Co	3	86,577
R. Gorrell & Co	1	86,311
A. C. Miller & Co	1	74,702
J. M. Freck & Co	1	68,438
Conner & Patterson	2	65,532
Bancroft, Lewis & Co	1	62,087
Glenville Coal Co	1	58,945
McNeal Coal & Iron Co	1	58,119
Black Diamond Coal & Iron Co.	2	55,402
Wiggan & Treibles	1	44,952
Althouse & Focht	1	40,870
Hill & Harris	1	40,144
George W. Cole	1	39,524
Suffolk Coal Co	2	39,083
J. & E. Silliman	1	38,593
Glendon Coal Co	1	37,619
Girard Mutual Coal Co	1	36,900
John Anderson & Co	1	36,332
Alter & Focht	1	35,348
Gilberton Coal Co	1	35,259
J. & O. O. Bowman	1	34,258
C. Garretson	1	31,784
Rathbun, Caldwell & Co	1	28,427
Knickerbocker Coal Co	1	27,602
Hartford Associated Coal Co	1	26,918
Continental Coal Co	1	23,875
J. Seitzinger & Co	1	23,431
Wm. Wadleigh, Agt	1	20,700
Schall & Donahue	1	17,957
Mahanoy Coal Co	1	16,154
East Mahanoy Coal Co	1	13,083
Boston and Mahanoy Coal Co	1	10,215
Coal Run Coal Co	1	12,3[illegible]
S. E. Griscom & Co	1	9,121
Buck & Collins	1	6,585
Wm. H. Sheafer	1	5,9[illegible]
Lee, Grant & Co	1	4,168
J. B. Reber & Co	1	2,185
Mt. Ætna Coal Co	1	928
Sundry	1	598
45 Firms,	55	1,823,655
In 1864		1,501,518
Increase in 1865		322,1[illegible]7

Nearly half the Coal mined in 1865, came from the Mahanoy and Shenandoah Regions.

SCHUYLKILL AND SUSQUEHANNA RAILROAD COAL TRADE.

The following is the quantity of Coal transported over the Schuylkill and Susquehanna Railroad in 1865 and the following years:

1865.	East.	West.	Total
From Pinegrove	143,502	18,458	161,9[illegible]
" Dauphin, West			20,625
" Auburn, West			4,169
			186,7[illegible]
In 1864	191,391	24,534	240,[illegible]
" 1863	189,254	48,449	237,705
" 1862	146,095	53,842	199,9[illegible]
" 1861	101,523	91,820	193,[illegible]43
" 1860	94,975	14,718	10[illegible]
" 1859	81,600	19,857	101,457
" 1858	60,435	43,493	103,92[illegible]
" 1857	44,801	37,484	82,2[illegible]
" 1856	42,393	34,914	77,307

This road is now owned and worked by the Reading Railroad Company.

SHAMOKIN COAL TRADE.

The following is the quantity of Coal sent from the Shamokin Coal Region by the different operators in 1865:

			Tons.
Cameron	Colliery	John Haas & Co.	66,114
Burnside	"	S. Bittenbender & Co.	29,158
Bear Valley	"	Shamokin and Bear Valley Coal Company	36,539
Henry Clay	"	John B. Douty, Agent	32,523
Big Mountain	"	Bird Coal and Iron Company	40,294
Buck Ridge	"	May, Patterson & Brother	41,522
Luke Fiddler	"	Burnside Coal and Iron Company	12,394
Lambert	"	John H. Dewees & Brother	16,528
Lancaster	"	Shamokin Coal Company	43,751
Crittenden	"	John B. Douty & Co.	13,919
Continental	"	Ballard & Co	4,136
Excelsior	"	John H. Dewees	18,572
Enterprise	"	Baumgardner & Co.	11,372
Green Mountain	"	S. John & Sons	14,732
Isaac Taylor	"	Hoover & Yarnall	4,596
Coal Mountain	"	Hough & Hersh	8,963
Stuartville	"	William Montelius	23,491
Coal Ridge No. 1	"	Schall & Donahoe	26,158
Coal Ridge No. 2	"	J. G. & G. S. Repplier	12,392
Daniel Webster	"	Sutton & Henry	10
			457,162
Total in 1864			333,478
Increase in 1865			123,684

LATERAL RAILROADS.

The following is the tonnage of the different lateral Railroads in Schuylkill County in the years 1864 and 1865.

	1864.	1865.	Increase.	Decrease.
Mine Hill and Schuylkill Haven	1,517,357	1,579,494	62,137	....
Mill Creek	436,163	326,367	..	109,796
Mahanoy and Broad Mountain	776,670	802,885	26,215	....
Schuylkill Valley	230,961	222,629	..	8,332
Mount Carbon	115,637	101,826	..	13,811
Little Schuylkill	537,396	585,534	48,138	....
Lorberry Creek	164,381	111,773	..	52,608
Swatara	46,835	46,067	..	768
	3,826,400	3,776,575		
Union Canal	212,216	157,840		54,376

The Coal that passed over the Union Canal Railroad is received from the Lorberry Creek and Swatara Roads. The Mahanoy Coal also passed on the Mill Creek Railroad, making the tonnage of that road, in 1864, 1,212,833 tons, and, in 1865, 1,129,252 tons.

PHILADELPHIA AND READING RAILROAD.

Points of supply and distribution of Anthracite Coal from Schuylkill county, and of Bituminous and Anthracite from Harrisburg, on the Philadelphia and Reading Railroad, for the year ending November 30th, 1865.

Amount of Coal received from the various Lateral Railroads in Schuylkill Coal Region:

Schuylkill Valley Railroad	95,294	
Mill Creek Railroad	228,296	
Mahanoy and Broad Mt. Railroad	702,926	
Ditto from Shamokin and Pottsville Railroad	9,895	
Total at Port Carbon		1,036,401
Mt. Carbon Railroad at Mt. Carbon		38,911
Mine Hill and Schuylkill Haven Railroad at Schuylkill Haven		1,072,836
Schuylkill and Susquehanna Railroad at Auburn		143,078
Little Schuylkill Railroad at Port Clinton		521,950
		2,813,176
Bituminous and Anthracite from Harrisburg and Dauphin		277,638
Total of all kinds		3,090,813

Where delivered on line of Reading Railroad:

Station or Turnout.	1864. Tons.	1865. Tons.	Station or Turnout.	1864. Tons.	1865. Tons.
Tremont	4	84	Conshohocken	12,001	8,157
Tamaqua	49	221	Egbert's	414	143
Cressona	146	619	Falls and Manayunk...	101,765	16,083
Pottsville	811	15,687	Nicetown & Germant'n.		95,175
Schuylkill Haven	1,908	1,955	Belmont	....	2,336
Orwigsburg	618	368	Philadelphia	373,070	380,233
Auburn	6,853	4,108	Port Richmond	2,058,423	2,051,302
Port Clinton	202	116			
Hamburg	2,747	3,022	LEBANON VALLEY BRANCH:		
Shoemakerville	1,479	2,531	Sinking Spring	10,854	39,630
Mohrsville	680	277	Wernersville & Heidelb'g	1,245	1,029
Leesport	1,816	4,843	Robesonia	15,269	15,345
Tuckerton	464	331	Wolemsdorf	1,388	1,564
Reading	163,027	147,697	Messemer's	470	323
Exeter	197	145	Richland	1,201	1,630
Birdsboro'	12,369	11,216	Myerstown	2,280	5,762
Douglassville	2,493	2,988	Lebanon	50,531	49,670
Pottstown	14,137	16,626	Annville	1,222	1,139
Limerick	1,011	1,799	Palmyra	1,107	1,365
Boyer's Ford	864	1,240	Derry	76	[illegible]
Phœnixville	72,577	67,557	Swatara	1,808	2,005
Valley Forge	619	1,108	Hummelstown	2,182	2,236
Port Kennedy	15,786	16,097	Beaver	28	172
Norristown	112,989	109,019	Harrisburg	1,071	153
Swede Furnace	11,963	4,756			
Rambo's Lime Kilns	3,601	3,816		3,065,577	3,090,314

LEHIGH COAL TRADE FOR 1865,

The following is the quantity of Coal sent to market from the Lehigh Region by the different firms and companies in 1865:

Operators.	Railroad.	Canal.	Total.
Lehigh Coal and Navigation Company	164	483,713	483,877
A Pardee & Co.	170,718	....	170,718
Honeybrook Coal Company	108,264	20,488	128,752
Packer & Co.	123,615	....	123,615
G. B. Markle & Co.	103,137	40,760	143,897
Sharpe, Weiss & Co.	83,248	22,163	105,411
German Pennsylvania Coal Company	45,048	22,400	67,448
Buck Mountain Coal Company	50,360	38,044	88,404
Harleigh Coal Company	49,585	15,870	65,455
Ebervale Coal Company	31,737	23,048	54,785
Stout Coal Company	37,835	18,906	56,741
Spring Mountain Coal Company	96,646	1,484	97,130
Thomas Hull & Co.	54,269	11,979	66,248
W. T. Carter & Co.	36,083	18,652	54,735
Taggart & Halsey	22,214	6,212	28,426
Lehigh Zinc Company	17,166	....	17,166
Beaver Meadow	3,022	....	3,022
John Connery	3,515	....	3,515
	1,046,626	723,669	1,770,295
From Schuylkill, Wilkesbarre, &c.	355,651	165,115	520,766
Total	1,402,277	888,784	2,291,061

SCHUYLKILL NAVIGATION COMPANY.

The following is the distribution of Coal *via* the Schuylkill Canal in 1864 and 1865:

Points of Distribution.	1864. Tons.	1865. Tons.
Port Carbon	831	1,670
Pottsville	410	249
Schuylkill Haven	1,337	1,149
Orwigsburg Landing	68	240
Auburn	......	22
Hamburg	1,765	2,078
Mohrsville	5,440	5,240
Althouses	14,228	12,912
Felix Dam	2,225	2,246
Reading	32,518	22,869
Birdsboro'	7,175	2,036
Mount Airy	7,549	3,883
Port Union	263	568
Pottstown	497	919
Springville	1,336	1,385
Royer's Ford	3,342	3,613
Black Rock Dam	788	638
Phœnixville	591	252
Pawling's Dam	132	128
Brower's Landing	570	346
Port Kennedy	456	103
Norristown	5,119	1,883
Conshohocken	7,933	1,824
Spring Mills	11,020	15,256
Manayunk	7,973	5,712
Baltimore	......	1,935
Salem	835	653
New Castle	1,504	1,723
Brandywine	6,867	7,869
Wilmington	19,500	20,871
Chester	12,834	10,193
Gloucester	465	1,952
Darby	1,985	1,697
Philadelphia	263,640	296,925
New York	578,706	591,672
Total	1,000,500	1,022,740

The supply for the line in 1865 was 87,250 tons, and sent south of Philadelphia 46,893 tons.

CONSUMPTION OF COAL ON THE LINES.

We have procured pretty full tables of the consumption of Coal on the lines of the different Railroads and Canals in 1865, which show that a very large quantity of Anthracite Coal is consumed before it reaches tide-water.

		Tons.
Philadelphia and Reading Railroad		659,379
Schuylkill Canal		87 250
Lehigh Valley Railroad		423,623
Lehigh Canal		82.235
Delaware Division		28,930
New Jersey Central		98,111
Belvidere and Delaware	about	50,000
Wyoming Canal	about	100,000
North Branch Canal		28.957
Lackawanna and Great Western Railroad North		264.293
" " " South		123,891
Bloomsburg and Lackawanna South	about	150,000
Delaware and Hudson Canal		10,825
Pennsylvania Coal Company		17.615
Morris Canal	about	40.000
Shamokin	about	40,000
Total tons		2,205,109

The above is all official, except from five points. Of the total supply of Anthracite in 1865, 9,488,396 tons, about 2,205,109 tons were consumed on the lines of the different avenues to tide-water and the interior. There were consumed on the line of the Schuylkill 746,629 tons, and on the Lehigh 505,858 tons.

COAL TRADE OF THE LINE.

The Trade of the Line between Pottsville and Philadelphia and on the Lebanon Valley Railroad, was as follows in the last sixteen years:

Years.	Railroad.	Canal.	Total.	Years.	Railroad.	Canal.	Total.
1850	166,992	40,871	207,836	1858	235,577	205,589	441,166
1851	199,650	112,697	312,836	1859	341,601	213,173	554,774
1852	189,661	132,550	322,211	1860	385,860	223,017	608,877
1853	238,328	155,750	394,078	1861	278,647	156,673	435,320
1854	283,212	160,949	441,160	1862	416,856	129,060	545.916
1855	294,385	187,476	481,861	1863	548,755	122,834	671.589
1856	329,365	191,139	520,499	1864	634,074	114,364	748,448
1857	313,178	198,799	511,977	1865	659,379	87,250	746.629

Of the tonnage on the Philadelphia and Reading Railroad for 1865, 620.275 tons were delivered at the following points on the line where there are Iron Works:

	Railroad.	Canal.	Total.
Leesport	4,843	12,912	17,755
Reading	147,697	28,869	176,566
Birdsboro	11,216	2,036	13,252
Pottstown	16,626	919	17,545
Phœnixville*	67,567	252	69,819
Norristown	109,019	1,883	110,901
Conshohocken	8,157	1,824	10,081
Spring Mills	....	15,256	15,256
Swede's Furnace	4,756	....	4,756
Manayunk Falls, Nicetown and Germantown	113,616	5,713	119,329
Robesonia (Lebanon Valley)	15,345	....	15,345
Lebanon (Lebanon Valley)	49,670	....	49,670
			620,275
Supply in 1864			655,798
Decrease at these points in 1865			35,523

* Caused by the stoppage of the Iron Works a considerable portion of the season.

QUANTITY SENT TO PHILADELPHIA.

The following is the quantity of Coal sent to Philadelphia in the following years, by Railroad and Canal:

Years.	Railroad.	Canal.	Total.
1855	342,311	286,087	628,398
1856	338,189	322,533	660,722
1857	320,327	387,479	707,806
1858	278,088	480,383	758,471
1859	286,791	512,670	799,461
1860	305,819	495,084	800,903
1861	273,473	473,965	747,438
1862	316,631	290,583	607,214
1863	388,352	237,563	625,915
1864	373,070	307,430	680,500
1865	380,233	296,925	677,158

The quantity of Schuylkill Coal consumed on the line of the Railroad and Canal exceeds the quantity delivered at Philadelphia for consumption.

The receipts of Coal at Port Richmond were as follows, since 1854:

Years.	Tons.
1855	1,576,596
1856	1,421,213
1857	1,076,187
1858	1,029,003
1859	1,004,540
1860	1,186,477
1861	909,112
1862	1,325,400
1863	2,128,154
1864	2,058,423
1865	2,051,202

The loss and gain for 1864 and 1865, at the following points, we sum up as follows:

	1864		1865	
	Loss.	Gain.	Loss.	Gain.
On the line	....	76,859	1,819	....
At Philadelphia	....	54,587	3,842	....
At Richmond	69,731	....	4,221	....
Eastern trade by Canal	....	53,560	....	12,966
	69,731	185,006	9,882	12,966
		69,731	....	9,382
Gain in 1864 and 1865		115,275		3,584

LEHIGH VALLEY RAILROAD.

The following is the distribution of Coal on the Lehigh Valley Railroad in 1864 and 1865:

Destination.	1864. Tons.	1865. Tons.
To Mauch Chunk.......	....	87
" " " *via* Canal.	....	....
Lehighton............	713	966
Parryville..............	18,463	23,529
Carbon Iron Co.........	....	......
Lehigh Gap............	292	212
Slatington............	765	1,581
Rockdale..............	140	276
Laury's................	37	59
Whitehall.....	521	742
Coplay.................	2,913	3,446
Lehigh Val. Iron Works.	26,751	26,122
Hokendauqua...........	102,201	73,238
Thomas Iron Co.........	....	....
Catasauqua.............	72,099	54,796
Lehigh Crane Iron Co...	....	....
Catasauqua Manuf. Co..	....	4,098
Catasauqua and F. R. R.	2,204	3,436
East Penn Iron Co......	....	1,808
Allent'n Furnace Station.	....	....
Allentown Iron Works..	57,109	48,028
Lehigh Rolling Mill.....	....	....
Allentown Rolling Mill..	19,993	19,287

Destination.	1864. Tons.	1865. Tons.
Roberts Iron Co.........	....	10,799
Jordon Manuf't'ring Co.	....	....
Allentown..............	17,596	13,579
East Penn R. R.........	9,341	8,845
Bethlehem..............	16,388	4,736
North Penn R. R........	123,475	129,695
Lehigh Zinc Co.........	....	24,105
Bethlehem Rolling Mill..	30,602	42,753
Freemansburg..........	347	415
Lime Ridge.............	307	62
Glendon Iron Works....	40,129	27,735
Easton..................	7,053	8,087
Delaware Canal.........	19,302	....
Phillipsburg, N. Jersey.	5,507	5,615
Morris Canal, "	44,600	73,965
Cooper Iron Works, "	13,306	13,651
Warren Foundry, "	....	....
Central R. R. of "	479,974	536,383
Belv. Del. R. R. N. J....	165,699	218,611
Morris and Essex R. R,..	....	496
Lehigh Valley R. R. Co..	17,589	21,636
Total.................	1,295,419	1,402,277

LITTLE SCHUYLKILL RAILROAD.

The following is the quantity of Coal transported over the Little Schuylkill Railroad, during the year ending November 30th, 1865.

Operators.	Tons.
Little Schuylkill Nav. R. R. & Coal Co., Reevesville Col.........	17,877
do. Shaft, No 1..................	14,290
do. Buckville...................	8,087
do. D. West.....................	6,798
do. New Kirk....................	1,337
	48,389
George W. Cole, Reevesdale Col......	13,370
Samuel Ratcliff, New Kirk Col.......	5,640
George Brown, Levan Col	13,872
George Ormrod, D. East Col.........	18,619
James Codrington, E. East Col......	1,661
Greenwood Coal Co., Greenwood Col.	71,369
Moss, Wood & Co., Lehigh Col......	21,757
Baughman & Stapleton..............	75

Operators.	Tons.
MAHANOY REGION.	
St. Nicholas Coal Co................	90,510
Glenville Coal Co...................	58,945
Hill & Harris........................	40,144
George W. Cole.....................	39,534
J. & E. S. Silliman.................	38,593
Alter & Focht.......................	35,345
Hartford Associate Coal Co..........	26,913
East Mahanoy Coal Co...............	13,683
T. F. Patterson & Co................	582
Thomas Gorman....................	167
Mahanoy & Broad Mountain Railroad.	35,047
Lackawanna Region.................	17,517
Total..........................	585,534

LEHIGH NAVIGATION COMPANY.

The following is the distribution of Coal carried by the Lehigh Navigation Company in 1865:

	Tons.
Consumed on line of Lehigh Canal	82,235
Entered Morris Canal at Easton	217,813
Entered Delaware and Raritan Canal	309,067
Consumed on line of Delaware Division	28,930
Arrived at Bristol	160,739
Total shipments in 1865	888,784

MORRIS CANAL COAL TRADE.

The following is a statement of the amount of Coal which entered the Morris Canal since 1845:

	LEHIGH COAL.			SCRANTON COAL.	
Year.	Canal. Tons.	Railroad. Tons.	Total. Tons.	Tons.	Total. Tons.
1845	12,567		12,567		12,567
1846	41,142		41,142		41,142
1847	61,951		61,951		61.951
1848	82,159		82,159		82,159
1849	103,482		103,482		103,482
1850	98,100		98,100		98,100
1851	137,237		137,237		137,237
1852	180,189		180,189		180,189
1853	222,582		222,582		222,582
1854	267,864		267,864		267,864
1855	290,730		290,730		290,730
1856	284,828	808	285,636	17,764	303,400
1857	227,652	13,047	240,699	43,599	284,298
1858	281,949	5,350	287,299	55,426	342,725
1859	255,405	5,780	261,185	89,146	350,331
1860	276,947		276,947	127,517	414,464
1861	272,616	1,401	274,017	140,922	414,939
1862	106,431	45,738	152,169	172,128	324,297
1863	208,397	48,234	256.631	145,815	402,446
1864	194,097	37,644	231,741	151,122	382,866
1865	217,814	74,171	291,985	124,204	416,189
	3,823,496	232,173	4,056,312	1,067,643	5,123,952

EAST PENNSYLVANIA RAILROAD COAL TRADE.

The Coal Trade of the East Pennsylvania Railroad from the Lehigh Region was,

	Tons.		Tons.
In 1860,	11,030	In 1863,	9,526
" 1861,	10,622	" 1864,	9,341
" 1862,	6,667	" 1865,	8,845

NORTH PENNSYLVANIA RAILROAD COAL TRADE.

Quantity transported over this Road from the Lehigh Region in the following years:

	Tons.		Tons.
In 1858,	73,124	In 1862,	103,947
" 1859,	80,432	" 1863,	113,680
" 1860,	91,327	" 1864,	123,475
" 1861,	98,389	" 1865,	129,695

NEW JERSEY CENTRAL RAILROAD COAL TRADE.

The following is the quantity of Coal transported over the New Jersey Central Railroad in the following years:

Year.	Lehigh. Tons.	Lackawanna. Tons.	Total. Tons.	Year.	Lehigh. Tons.	Lackawanna. Tons.	Total. Tons.
1856	33,325	98.670	131,194	1861	254,367	568,869	823,235
1857	84,881	209,950	294,791	1862	311,296	502,375	816.571
1858	122,923	417,726	540,549	1863	435,729	613,954	1,049.683
1859	180.054	461,430	641,487	1864	474,221	675,743	1,149.964
1860	263,885	590,862	854,647	1865	509,619	494,687	1,004,306

Of the above quantity 87.217 tons Lehigh and 10,895 tons Lackawanna—in all 98,111 tons—were used on the line; the balance reached Elizabethport.

BELVIDERE AND DELAWARE RAILROAD COAL TONNAGE.

The following is the quantity of Coal transported over this Road, received from the Lehigh Region in the following years:

	Through.	Way.	Total.		Total.
In 1865	202,781	11,585	214,345	In 1860	146.308
" 1864	161,278	13,095	174,323	" 1859	135,205
" 1863			130,494	" 1858	99,090
" 1862			129,452	" 1857	123,248
" 1861			145,907		

CATAWISSA RAILROAD COMPANY.

The following is the Coal tonnage that passed over this Road in the following years:

Year.	Lacka. Tons.	Lehigh. Tons.	McCauly Mt. Tons.	Bitu. Tons.	Total. Tons.
1861	6,553	6,220	1,997	1,029	15,799
1862	46,689	85,539	3,282	1,536	137,046
1863	101.934	43,887	7,477	308	153,606
1864	No Report.				
1865	22,286	3,367	546	6,004	32.203
	177,462	139,013	13,302	8,877	340,654

THE DELAWARE, LACKAWANNA AND WESTERN RAILROAD COMPANY.

Coal Business of 1865.

	Tons.
Total shipments since opening of road	9,620,701
Mined and delivered in 1865 for account of D. &. L. R. R. Co	930,277
Shipped to Oxford Furnace, do. S. T. Scranton & Co	7,666
Shipped to Elizabethport, do. Susquehanna & Wyoming Valley Railroad and Coal Company	55,097
Shipped to do. do. Roaring Brook Coal Company	10,388
Shipped do. do. Lackawanna & Susquehanna Coal & Iron Co	3,459
Total	1,006,887
Of amount sent away in 1865 there were mined by D. & L. R. R. Co	579,615
Ditto. other parties	427,272
Total	1,006,887

	1864.	1865.
Amount sold at mines	2,984	923
" shipped north	342,382	271,519
" " south	957,747	734,445
	1,303,117	1,006,887
	1,006,887	
Decrease from 1864	296,226	

Distribution of the Coal.

Sold at mines	923
Scranton and north division	41,110
Binghamton & Chenango Coal	54,418
Syracuse and for shipment	125,878
Ithaca do	41,736
Line of Erie Railway and connecting roads	8,347
Elizabethport	541,879
Line of Central Railroad of New Jersey	12,202
Washington & Morris' Canal	152,418
South Division D. & L. R. R	27,946
Total	1,006,887

AMOUNT OF COAL USED IN THE PRODUCTION OF IRON IN THE UNITED STATES.

In the production of Anthracite Pig-Iron, about two tons of coal is required to produce the ton of pig. In the coke and raw coal furnaces, three tons of coal is near the average use to the ton of metal produced; and in the Rolling Mills generally, three tons of anthracite coal is used per ton of T rails made, but a larger amount is required to produce small merchant bar.

	Tons Iron made.	Tons of Coal used to produce the Ton of Iron.	Tons Coal used.
Anthracite Iron	684,319	2	1,368,638
Coke and Raw Coal Iron	210,108	3	630,324
Rolled Iron	335,369	3	1,006,107

DELAWARE AND HUDSON CANAL COMPANY.

PROVIDENCE, PA., *January 1st*, 1866.

Statement of the amount of Coal mined and forwarded on the Railroad of this Company for the year ending December 15th, 1865, with the sources whence received:

Carbondale, D. & H. Canal Co's mines	255,735	
Olyphant do. do. do.	174,850	
Providence, do. do. do.	134,589	
		565,174
Rushdale, John Jermyn	65,171	
Archbald, Eaton & Co	81,781	
Archbald, Boston & Lackawanna Coal Co	63,488	
Dickson, Elk Hill Coal Co	26,480	
		246,921
Total for 1865		812,094
Total for 1864		886,841
Decrease in 1865		74,747

COAL TRADE OF ELIZABETHPORT.

The following is the quantity of Coal received at Elizabethport, New Jersey, by the different Companies and Shippers in 1865:

	Tons.		Tons.
Scranton Coal, by D. L. W. R. R.	383,792	Wilksbarre Coal and Iron Co	23,080
S. Bonnel, Jr	105,531	Van Dusen, Lockman & Co	18,624
L. Audenried & Co	84,952	Rathbun, Caldwell & Co	16,077
E. A. Packer & Co	60,577	Consolidated Coal Co	7,041
A. Pardee & Co	39,456	Day & Huddell	6,745
A. T. Stout & Co	33,220	E. A. Quintard & Co	1,063
Randolph & Brothers	23,906	Sundry Shippers	2,111
Total			906,195

Of which 422402 tons were from the Lehigh, Schuylkill and Wilkesbarre Regions, independent of that sent from Scranton by the Delaware, Lackawanna and Western Railroad Company.

BLOSSBURG AND BARCLAY COAL TRADE.

Years.	Blossburg.	Barclay.	Years.	Blossburg.	Barclay.
1840	4,235	....	1854	70,454	....
1841	25,966	....	1855	73,201	....
1842	13,164	....	1856	70,670	4,115
1843	6,268	....	1857	94,314	6.239
1844	14,234	....	1858	41,805	17,560
1845	29,836	....	1859	51,441	30.143
1846	16,509	....	1860	97,571	27.718
1847	29,087	....	1861	112,713	40.835
1848	33,762	....	1862	179,334	52.779
1849	32,095	....	1863	226,183	54,116
1850	23,161	....	1864	353,124	62.000
1851	25,000	....	1865	394,631	68,463
1852	20,000	....			
1853	45,571	....		1,689,698	296,005

BITUMINOUS COALS.

GREAT CENTRAL COAL FIELD—1864.

	Tons.
Illinois	1,000,000
Indiana	500,000
Western Kentucky	250,000
Missouri and Iowa	500,000
	2,250,000
Michigan Coal Field	100,000
Total	2,350,000

TABLE OF BITUMINOUS COAL MINED IN THE ALLEGHENY COAL-FIELD IN PENNSYLVANIA—1864.

	Tons.
*Barclay Coal & Railroad Company	54,000
Ralston and vicinity	20,000
*Blossburg	385,000
Lock Haven and Tyrone Railroad, &c.	45,000
*On line of Philadelphia and Erie Railroad	27,000
*Connellsville & Pittsburg Railroad	146,000
*Pennsylvania Central Railroad	960,000
*Pennsylvania Canal	32,000
Juniata River	239,712
*Monongahela Navigation	1,170,000
On the line of the Youghiogheny River	500,000
On the line of the Allegheny River	500,000
Furnaces and Mills on the Conemaugh River	800,000
All other localities	1,000,000
Total tons of 2000 pounds	†5,870,712

TABLE OF COAL PRODUCED FROM THE ALLEGHANY COAL-FIELD IN 1864.‡

	Tons.
Pennsylvania	5,870,712
Ohio	1,000,000
Maryland	657,996
West Virginia	500,000
Kentucky	250,000
Tennessee	500,000
Alabama	300,000
Total tons of 2000 pounds	9,078,708

* Official.

† In this Table we make a slight change from that given on page 331, and have divided the figures opposite "Johnstown and vicinity" between the *Conemaugh* and *Juniata* rivers.

‡ The amounts for the Southern States are calculated before the war in 1861.

STATISTICS OF THE CUMBERLAND COAL TRADE FROM ITS COMMENCEMENT.

Compiled from Official Sources, by C. Slack, *Mount Savage, Md.*

TABLE No. 1.—DETAILS OF 1865.

NAME OF COMPANY.	1865.				Compared with 1864.	
	To B. & O. R. R.	To C. & O. Canal.	LOCAL.	TOTAL.	Increase.	Decrease.
	TONS.	TONS.	TONS.	TONS.	TONS.	TONS.
American Coal Company.......	23,756	64,800	362	88,918	25,109	....
Central C. M. & M. Company.	42,774	59,427	8	102,209	42,660	....
Piedmont Coal and Iron Co....	31,799	....	......	31,799	9,537	....
Swanton Mining Company.....	34,018	2,397	......	36,415	14,959	....
Potomac Coal Company.........	32,482	....	......	32,482	6,422	....
George's Creek C. & I. Co......	44,326	111	339	45,276	2,067	....
Hampshire & Baltimore C. Co.	3,926	36,888	......	40,814	21,766	....
Neff Run Coal Company.........	799	1,881	......	2,680	....	11,124
Frostburg Coal Company.......	....	....	......	....	....	15,019
Consolidation Coal Company..	18,146	24,839	15,113	58,098	24,457	....
Borden Mining Company.......	17,273	43,210	116	60,599	7,499	....
New Hope Mines....................	9,822	28,069	45	37,936	8,949	....
Midlothian Coal Company......	5,161	14,863	26	20,050	11,763	....
Barton Coal Company...........	5,099	5,197	......	10,296	3,185	....
Atlantic & G. C. C. Company.	16,519	....	......	16,519	16,294	....
Savage Mountain Coal Co......	1,652	3,613	8	5,273	5,273	....
George's Creek Mining Co.....	38,652	....	......	38,652	17,931	....
Franklin Coal Company.........	41,576	....	......	41,576	....	3,382
Cumberland Iron & Coal Co...	66,900	57,800	3,180	127,880	5,464	....
Blaen-Avon Coal Company....	24,362	107	......	24,469	15,118	....
Spruce Hill Coal Company.....	10,209	....	......	10,209	9,778	....
Hampshire & Baltimore C. Co.	70,365	....	980	71,345	26,793	....
	540,116	343,202	20,177	903,459	275,024	29,525
					29,525	
					245,499	Increase

RECAPITULATION.

By Cumberland & Pennsylvania R. R. to Baltimore & Ohio R. R......	368,280	
" " " to Chesapeake & Ohio Canal...	285,295	
" " " to Local.............................	16,017	
		669,592
By Cumberland Coal and Iron Co. to Baltimore and Ohio Railroad...	101,471	
" " " to Chesapeake and Ohio Canal....	57,907	
" " " to Local..................................	3,180	
		162,558
By Hampshire & Baltimore R. R. to Baltimore and Ohio Railroad...	70,365	
" " " to Local.....	980	
		71,345
Total..		903,495

No. 2.

THE CUMBERLAND COAL TRADE.—From 1842 to 1865, inclusive—24 years.

	FROSTBURG REGION.						PIEDMONT REGION.				Total by Baltimore and Ohio Railroad.	Total By Chesapeake and O. Canal.	Aggregate
	CUMBERLAND AND PENNSYLVANIA R. R.			CUMBERLAND COAL AND IRON COMPANY'S R. R.			GEORGE'S CREEK RAILROAD.			HAMP. R. R.			
	By B. & O. R. R.	By C. & O. Canal.	TOTAL.	By B. & O. R. R.	By C. & O. Can.	TOTAL.	By B. & O. R. R.	By C. & O. Canal	TOTAL.	By B. & O. R. R.			
	TONS.	TONS.	TONS.	TONS.	TONS.	TONS.	TONS.	TONS	TONS.	TONS.	TONS.	TONS.	TONS.
1842	757	....	757	951	....	951	....	....	....	....	1,708	....	1,708
1843	3,661	....	3,661	6,421	....	6,421	....	....	....	....	10,082	....	10,208
1844	5,156	....	5,156	9,734	....	9,734	....	....	....	....	14,890	....	14,890
1845	13,738	....	13,738	10,915	....	10,915	....	....	....	....	24,653	....	24,653
1846	11,240	....	11,240	18,555	....	18,555	....	....	....	....	29,795	....	29,795
1847	20,615	....	20,615	32,325	....	32,325	....	....	....	....	52,940	....	52,940
1848	36,571	....	36,571	43,000	....	43,000	....	....	....	....	79,571	....	79,571
1849	63,676	....	63,676	78,773	....	78,773	....	....	....	....	142,449	....	142,449
1850	73,783	3,167	76,950	119,023	875	119,898	....	....	....	....	192,806	4,042	196,848
1851	70,893	51,438	122,331	103,808	31,540	135,348	....	....	....	....	174,701	82,978	257,679
1852	128,534	46,357	174,891	139,925	19,362	159,287	....	....	....	....	268,459	69,719	334,178
1853	150,381	84,060	234,441	155,278	70,535	225,813	70,560	3,165	73,725	....	376,219	157,760	533,979
1854	143,953	63,731	212,684	173,580	92,114	265,694	181,303	....	181,303	....	503,836	155,845	659,681
1855	93,961	77,095	171,056	97,710	100,691	198,401	221,245	6,000	227,245	65,570	478,486	183,786	662,272
1856	86,994	80,387	167,381	121,945	105,149	227,094	250,626	18,584	269,210	42,765	502,330	204,120	706,450
1857	80,743	55,174	135,917	88,573	54,000	142,573	244,968	7,400	252,368	51,628	465,912	116,674	582,486
1858	48,018	166,712	214,730	66,009	87,439	153,548	218,318	....	218,318	63,060	395,405	254,251	649,656
1859	48,415	211,639	260,054	72,423	86,203	158,626	257,740	....	257,740	47,934	426,512	297,842	724,354
1860	70,669	232,278	302,947	80,500	63,600	144,100	289,298	....	289,298	52,564	493,031	295,878	788,909
1861	23,878	68,303	92,181	25,983	29,296	55,279	85,554	....	85,554	36,660	172,075	97,599	269,674
1862	71,745	75,206	146,951	41,096	23,478	64,574	69,482	....	69,482	36,627	218,950	98,684	317,634
1863	117,796	173,269	291,065	111,087	43,523	154,610	266,430	....	266,430	36,240	531,553	216,792	748,345
1864	287,126	194,120	481,246	67,676	64,522	132,198	....	....	....	44,552	399,354	268,642	637,996
1865	384,297	285,295	669,592	104,651	57,907	162,558	....	....	... .	71,345	*560,293	343,202	903,495
	2,041,600	1,868,231	3,909,831	1,769,941	930,334	2,700,275	2,155,524	35,149	2,190,673	548,945	6,516,010	2,833,714	9,349,724

* Includes 21,177 tons used on line of Cumberland and Pennsylvania Railroad, the local consumption at Piedmont and Cumberland; also, 114,800 tons used by the Baltimore and Ohio Railroad Company.

ANTHRACITE COAL TRADE OF PENNSYLVANIA.

The following Table exhibits the Anthracite Coal sent to Market from the different Regions in Pennsylvania, from the Commencement of the Trade in 1820 to 1865, inclusive.

HARD ANTHRACITES.

Years.	Schuylkill.					Sold on Line of Schuylkill.	Lehigh.		
	Canal.	Railroad.	Total.	Pinegrove.	Little Schuylkill.		Canal.	Railroad.	Total.
1820	....	....	....	....	....	....	365	....	365
1821	....	....	....	....	....	....	1,073	....	1,073
1822	1,480	....	1,480	....	....	....	2,240	....	2,240
1823	1,128	....	1,128	....	....	....	5,823	....	5,823
1824	1,567	....	1,567	....	....	....	9,541	....	9,541
1825	6,500	....	6,500	....	....	....	28,393	....	28,393
1826	16,767	....	16,767	....	....	....	31,280	....	31,280
1827	31,360	....	31,360	....	....	....	32,074	....	32,074
1828	47,284	....	47,284	....	....	3,154	30,232	....	30,232
1829	79,973	....	79,973	....	....	3,332	25,110	....	25,110
	186,059		186,059			7,486	166,131		166,131
1830	89,984	....	89,984	....	....	5,321	41,750	....	41,750
1831	81,854	....	81,854	....	....	6,150	40,966	....	40,966
1832	209,271	....	209,271	....	14,000	10,048	70,000	....	70,000
1833	252,971	....	252,971	....	40,000	13,4[illegible]9	123,000	....	123,000
1834	226,692	....	226,692	....	34,000	19,429	106,244	....	106,244
1835	339,508	....	339,808	....	41,000	18,571	131,250	....	131,250
1836	432,045	....	432,045	....	35,000	17,863	148,211	....	148,211
1837	523,152	....	523,152	17,000	31,000	21,749	223,902	....	223,902
1838	433,875	....	433,875	13,000	13,000	28,775	213,615	....	213,615
1839	442,608	....	442,608	20,539	9,000	30,390	221,025	....	221,025
	3,031,960		3,031,960	50,539	217,000	171,725	1,319,963		1,319,963
1840	452,291	....	452,291	23,860	20,000	28,924	225,318	....	225,318
1841	584,692	850	585,542	17,653	40,000	41,223	143,037	....	143,037
1842	491,602	49,902	541,504	32,381	37,000	40,584	272,546	....	272,546
1843	447,058	230,254	677,312	22,903	31,000	34,619	267,793	....	267,793
1844	398,887	441,491	840,378	34,916	57,000	60,000	377,002	....	377,002
1845	263,587	820,237	1,083,796	47,928	74,000	90,000	429,453	....	429,453
1846	3,440	1,233,142	1,236,582	58,926	91,000	155,460	517,116	....	517,116
1847	222,693	1,360,681	1,583,374	67,457	106,491	226,610	633,507	....	633,507
1848	436,602	1,216,233	1,652,835	61,530	162,626	252,837	670,321	....	670,321
1849	489,208	1,115,918	1,605,126	78,299	174,758	239,290	781,656	....	781,656
	3,790,360	6,468,708	10,358,740	445,865	793,798	1,169,547	4,317,749		4,317,749
1850	288,030	1,423,977	1,712,007	70,919	211,960	207,863	690,456	....	690,456
1851	579,156	1,650,270	2,229,426	....	310,307	312,367	964,224	....	964,224
1852	800,038	1,650,912	2,450,950	66,543	325,099	322,211	1,072,136	....	1,072,136
1853	888,695	1,582,248	2,470,943	80,660	389,295	394,078	1,054,309	....	1,054,309
1854	907,354	1,987,854	2,895,208	91,462	444,184	444,160	1,207,186	....	1,207,186
1855	1,105,263	2,213,292	3,318,555	112,213	426,208	471,861	1,275,050	9,063	1,284,113
1856	1,169,453	2,088,903	3,258,356	157,152	454,515	520,499	1,186,230	165,740	1,351,970
1857	1,275,989	1,709,552	2,985,541	145,012	346,877	511,977	900,314	418,235	1,318,541
1858	1,323,804	1,542,645	2,866,449	137,376	383,931	441,166	909,000	471,030	1,380,030
1859	1,372,021	1,632,932	3,004,953	125,262	366,348	554,774	1,050,659	577,652	1,628,311
	9,709,803	17,482,585	27,192,390	986,599	3,658,719	4,181,156	10,309,564	1,641,720	11,951,286
1860	1,356,688	1,878,156	3,270,516	152,957	323,136	608,877	1,091,032	730,642	1,821,674
1861	1,183,570	1,460,832	2,697,489	167,357	171,432	435,320	994,705	743,672	1,738,377
1862	981,729	2,305,606	2,890,598	183,985	249,451	545,916	396,227	882,573	1,351,054
1863	885,842	3,065,261	3,433,265	212,794	385,788	671,589	699,558	1,195,155	1,894,713
1864	1,000,500	3,065,577	3,642,218	211,216	537,498	748,448	738,067	1,293,419	2,054,669
1865	1,022,740	3,090,814	3,735,802	157,840	585,534	746,629	886,784	1,402,277	2,040,913
	23,143,161	38,767,639	60,422,057	2,569,142	6,922,106	9,266,693	20,942,800	7,861,458	28,634,299

ANTHRACITE COAL TRADE OF PENNSYLVANIA.

The following Table exhibits the Anthracite Coal sent to Market from the different Regions in Pennsylvania, from the commencement of the Trade, in 1820, to 1865, inclusive.

HARD ANTHRACITES.

BROAD TOP SEMI-BITUMINOUS COAL REGION.

Statement exhibiting the amount of Coal Mined and sent to Market in 1865, from the Collieries of the Broad Top Coal Regions, with present facilities and estimated capacity for 1866, furnished by John Fulton, Mining Engineer.

NAME OF COLLIERY.	NAME OF PROPRIETOR.	NAME OF OPERATOR.	Tons net sent to market in 1865.	Length of gangways. Feet.	Number of miners at work.	No. of other workmen.	No. of miners' houses at collieries.	No. of galleries and rooms in working order.	Average capacity in tons per day.	Estimated value of colliery improvements and fixtures.
Coalmont	Broad Top Coal and Iron Co.	Broad Top Coal and Iron Co	1,439	1,500	26	8	8	10	75	$75,000
Crawford	H. and B T. R R and Coal Co.	Miller & Maguire	7,027	2,683	25	8	17	9	60	15,000
"	Powelton Coal and Iron Co.	Powelton Coal and Iron Co.	64,431	13,920	100	68	71	170	360	125,000
	" "	" "	15,003	600	48	6	1	40	150	30,000
	Orbison, Dorris & Co.	W. A. Orbison	446	300	7	4	......	6	30	5,000
	" "	"	26,362	7,000	58	12	13	58	250	30,000
	Wood & Bacon	R. B. Wighton	14,430½	2,346	37	16	20	20	150	40,000
	David Blair	Blair & Port	5,380	3,659	24	5	10	12	100	20,000
	Cummings & Hartman	Reakirt & Brother	8,161	1,756	27	6	14	13	100	30,000
	" "	"	......	600	......	......	......	......	......	5,000
	Semi-Anthracite Coal Co.	J. W. Ammerman & Co.	16,639	3,085	54	9	15	27	180	15,000
	" "	" "	......	1,800	......	......	28	......	......	10,000
	Jesse Cook	George Mears	17,004	2,957	40	6	26	66	300	20,000
	H. and B. T. R. R. and Coal Co	"	968	480	22	4	......	12	70	15,000
	Broad Top Improvement Co.	Blair & Port	9,343	2,315	......	......	15	13	30	15,000
	Jesse Cook	Cook, Sheets & Co.	3,389	900	30	3	4	13	70	15,000
	Riddlesburg Coal and Iron Co.	Riddelsburg Coal and Iron Co.	14,948	3,560	20	8	24	30	200	40,000
	H. and B. T. R. R. and Coal Co.	H. and B. T R. R. and Coal Co.	1,852	600	24	12	15	15	150	35,000
	A. P Wilson	Wm. Brewster	2,523	1,445	......	......	6	7	30	10,000
	R. B Wighton	R. B. Wighton	15,280	1,684	34	12	23	15	100	20,000
	Reed,	Dunn & Lawrence	18,231	2,630	45	6	16	33	150	30,000
	Scott,	J. Maguire & Son	5,204	797	......	1	11	13	60	40,000
	Rathm	Noble, Caldwell & Co.	31,304	1,800	44	9	30	50	300	40,000
	"	" "	12,370	900	20	4	11	20	120	15,000
	Six Mile Run Coal Co.	John Rommel, Jr.	198	717	10	3	13	......	......	20,000
	" "	"	710	1,392	30	6	14	20	180	25,000
	Hopewell Coal and Iron Co.	R. Langdon	3,316	1,100	20	6	13	30	60	10,000
Totals			316,096¼	68,335	759	230	416	736	3,145	$712,000

COAL FIELDS OF THE WORLD AND THEIR PRODUCTIONS.*

	Area of Coal-fields in Square Miles.	Productions in 1864. Tons.
British Islands	6,195	86,000,000
United States	200,000	22,000,000
Prussia and Saxony	1,000	12,000,000
France	1,000	10,000,000
Belgium	510	10,000,000
Austria and Bohemia	1,000	2,500,000
Spain	200	400,000
Arcadia	2,200	500,000
Total coal production of the world		143,400,000

TABLE OF BRITISH COAL PRODUCTION.

Years.	No. of Tons.	Value at 5s. per Ton at the Place of Production.	Years.	No. of Tons.	Value at 5s. per Ton at the Place of Production.
1845	31,500,000	£7,875,000	1859	71,979,765	17,994,941
1850	50,000,000	12,500,000	1860	80,042,698	20,010,674
1854	64,661,401	16,165,350	1861	83,635,214	20,908,803
1855	61,453,079	16,113,267	1862	81,638,338	20,409,584
1856	66,645,450	16,663,862	1863	86,292,215	21,573,053
1857	65,394,707	16,348,676	1864†	90,000,000	$110,000,000
1858	65,008,649	16,252,162			

PRODUCTION OF BITUMINOUS COAL IN THE UNITED STATES.

	1864—Tons.	1865—Tons.
Alleghany Coal Field	9,078,708	9,078,708
Do. Increase in Maryland in 1865	....	245,499
Do. Increase in Pennsylvania in 1865	....	250,000
Central Coal Field	2,250,000	2,250,000
Increase in Illinois in 1865	....	100,000
Northern or Michigan Coal Fields	100,000	100,000
East Virginia and North Carolina	200,000	....
	11,628,708	11,974,207
Decrease in the Southern States in 1865		600,000
Total Bituminous production in 1865		11,324,207
Anthracites		11,532,732
Total United States		22,856,939

* In our comprehensive Table on page 86 we have given Austria credit for much that really belongs to Prussia, hence the difference.

† Reported production, not official. Value estimated in dollars, at $1.25 per ton. These, however, are all low values, since the coal is frequently worth seven shillings per ton at the place of production.

SEMI-ANTHRACITE AND BITUMINOUS COAL.

* For importation of foreign coals, see second column of the next table—giving a total of [illegible],127 tons, deducting which from [illegible],842 tons, leaves 37,460,[illegible] tons as the Semi-Anthracite and Bituminous production.

RECAPITULATION OF THE COAL TRADE OF THE UNITED STATES.

Years.	Import of Foreign Coal.	Increase and Decrease of Bituminous Coal.	Hard Anthracite Coal.	Aggregate of all Kinds.	Total Increase and Decrease.	Exportation Domestic Coal.
1820	....	....	365	365		
1821	22,122	22,122	1,073	23,195	22,830	
1822	34,523	12,401	3,720	38,243	15,052	
1823	30,433	d4,090	6,951	37,384	d:69	
1824	7,228	d30,156	11,108	18,336	d25,999	
1825	25,645	18,417	34,893	60,338	42,205	
1826	35,665	10,020	48,047	83,712	23,174	
1827	40,257	4,592	63,434	103,691	19,979	
1828	32,302	d7,955	77,516	109,818	6,127	
1829	45,393	13,091	112,083	157,476	47,658	
	273,568		359,190	636,903		
1830	58,136	12,743	174,734	232,870	75,394	
1831	36,509	d21,637	176,820	213,329	d19,541	
1832	72,978	36,496	363,871	436,329	223,520	
1833	92,432	19,454	487,748	580,180	143,331	
1834	71,626	d20,806	376,636	448,262	d131,918	
1835	49,969	d21,657	560,758	610,727	162,465	
1836	108,432	58,463	684,117	792,549	181,822	
1837	153,450	45,028	879,444	1,032,894	240,345	
1838	129,083	d24,367	738,697	867,780	d165,114	
1839	181,551	52,468	818,402	999,953	132,173	
	954,166		5,261,197	6,015,443		
1840	162,867	d18,684	864,384	1,027,251	27,298	
1841	155,394	d7,473	959,973	1,115,367	88,116	
1842	141,521	d12,167	1,108,418	1 251,645	136,278	
1843	41,163	d91,962	1,263,598	1,314,843	63,198	
1844	87,079	50,718	1,630,850	1,732,813	417,970	
1845	85,776	8,466	2,013,013	2,123,443	390,630	
1846	156,853	66,219	2,344,095	2,520,653	397,210	
1847	148,021	24,313	2,882,309	3,088,170	567,517	
1848	196,166	74,778	3,089,238	3,364,977	276,807	9,309
1849	198,213	90,248	3,217,641	3,583,628	218,651	9,661
	1,373,049		19,373,426	21,109,575		85,189
1850	180,439	50,063	3,321,136	3,736,186	182,558	38,741
1851	214,774	131,603	4,329,530	4,876,183	1,139,997	37,727
1852	183,015	64,036	4,899,975	5,510,664	644,481	45,336
1853	231,508	251,806	5,097,144	5,959,639	448,976	79,510
1854	262,865	209,169	5,831,834	6,903,498	943,859	95,894
1855	287,408	d1,731	6,486,097	7,556,030	652,532	110,585
1856	173,055	57,484	6,751,542	7,858,959	302,929	136,594
1857	238,192	64,328	6,431,378	7,593,118	d265,841	130,355
1858	259,885	87,804	6,524,838	7,774,388	181,270	118,304
1859	281,206	122,721	7,517,516	8,889,787	1,115,399	161,492
	2,302,349		56,954,864	66,169,401		942,529
1860	240,697	113,246	8,143,938	9,629,455	739,668	187,039
1861	583,115	d126,225	7,621,854	8,980,646	d648,898	158,171
1862	545,433	428	7,499,556	9,015,504	d121,371	216,438
1863	660,086	475,589	9,427,619	11,560,356	2,412,663	173,021
1864	510,708	d77,157	9,998,046	23,347,984	487,231	175,039
1865	685,052	319,106	9,488,396	22,856,989	491,045	132,438
	8,068,127		134,121,549	178,795,634*		

* This includes the Western Bituminous coal trade for 1864 and 1865, which was not previously reported.

STATISTICAL TABLE OF THE ANTHRACITE REGIONS.

NAME OF REGION.	Number of collieries.	No. of steam engines.	Horse power of steam engines.	Number of Men and boys employed.	Average production per head per annum. Tons.	Coal production in tons for 1865.	Capital employed in mining coal.
Lehigh Coal Basins	60	153	6,728			2,040,913	$10,000,000
Lehigh Region*	10	20	3,430				
Schuylkill Region†	92	330	18,500			2,050,000	11,000,000
Mahanoy Region	55	100	4,000			1,623,653	7,500,000
Shamokin Region	23	36	1,330			457,162	2,500,000
Wyoming and Lackawanna	65	164	7,475			3,254,619	9,000,000
	313	792	41,453	80,000	206	9,626,247	$40,000,000

PRODUCTIONS PER CAPITA.

In the Lehigh regions but little development comparatively has been done during the last two years, consequently a greater production per head per annum is apparent; but in reality there has been a greater production of coal per head per annum by each person actually engaged in getting coal in the Mahanoy region. In the Shamokin region likewise, a large number of the workmen has been engaged in opening and developing mines instead of digging and preparing coal. The Wyoming and Lackawanna regions also appear to disadvantage, because many of the mines there are suspended during the winter season. There can be no doubt, however, but the Schuylkill production is behind all other regions, on account of the great depth of the mines, the imperfect improvements and machinery at many of the old collieries, the comparative smallness of many of the seams worked, and other causes.

In all the regions enumerated, except the Lehigh, a large portion of the time was lost during 1865, which tended materially to reduce the quantity of coal produced per head. An average production during favorable seasons is about 300 tons per head per annum, or one ton for each man and boy employed per day.

This, however, is a very unsatisfactory and limited production from our large coal beds, and plainly condemns the system pursued, since the average production per head per annum in the Great Northern, or Newcastle coal field, where the seams are only from three to five feet thick, is 500 tons.

* Eastern end of First or Southern Coal Field.

† Including Lykens' Valley, but not Dauphin.

During 1854 there were 64,739,789 tons of coal mined in Great Britain, and 146,496 men and boys employed at the mines, inside and outside. This gives as the average production of the British mines about 440 tons per head per annum, while the Newcastle production is over 500 tons per man and boy per annum.

We have no reliable statistics of the Cumberland region, but from the Broad Top region our data is complete. The amount of coal produced in 1865 were 315,996 tons, and the number of men and boys employed inside and outside 965, which gives a production of 426 tons per head per annum.

In the Department of the Nord, France, where the coal seams are very thin, from two to three feet thick, the production per capita is only 105 tons; but, in the Department of the Loire, where the coal-beds are thick, the production per capita is 244 tons per capita.

CAPITAL INVESTED IN THE ANTHRACITE COAL TRADE.

In the preceding Table we have given a close estimate of the amount of capital actually employed in mining, or the production of coal, at $40,000,000. This includes all improvements at the collieries, but not the value, or capital invested in coal lands, railroads, &c.

The value of the coal lands are estimated for the several regions, at an average of $250 per acre. Good coal lands can still be purchased at $150 per acre, but they also command $1000 in favorable localities. The entire area of the anthracite coal fields is estimated at 470 square miles. We will accept, however, 500 square miles, or 320,000 acres, as the amount of land available, or that which may be bought and sold as coal lands, since it is seldom that a large coal tract can be purchased without taking in a portion of unproductive territory. At $250 per acre, which is extremely low, since English coal lands, containing one half the workable thickness of coal, sell readily at $5,000 per acre—the value or capital represented by our mineral lands in the anthracite regions is $80,000,000.

The capital invested in railroads and canals penetrating these coal fields, built principally for their development, and sustained by the coal trade, is $170,000,000, not including the Northern Central and New Jersey Central railroads. The Cattawissa, Northern Central and New Jersey Central are not included in the above estimate on our tables, as they were not built expressly for the transportation of coal.

RECAPITULATION.

Capital invested in Mining	$40,000,000
" represented by Coal Lands	80,000,000
" " Railroads	70,000,000
" " Canals	40,000,000
Total	$230,000,000

[illegible] REGIONS, 1864.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Length of track laid, including sidings—miles.	Length of Main Line—miles.	Cost.
[illegible] R.R.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	8	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	4	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	[illegible]	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	[illegible]	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	[illegible]	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	4	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	[illegible]	1,[illegible]
[illegible] R.R.	—	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]
[illegible] R.R.	—	—	—	—	—	[illegible]	[illegible]	[illegible]
[illegible] R.R.	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	14	1,[illegible]
[illegible] R.R.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70	[illegible]
[illegible] R.R. [illegible]	—	—	—	—	—	[illegible]	[illegible]	
[illegible] R.R. [illegible]	—	[illegible]			[illegible]	[illegible]	[illegible]	2,[illegible]
[illegible] R.R.	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	14	1,[illegible]
[illegible] R.R. [illegible]	[illegible]					[illegible]	[illegible]	[illegible]
[illegible] R.R.	[illegible]	4	[illegible]		[illegible]	[illegible]	[illegible]	2,[illegible],000
[illegible] R.R.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible],450
[illegible] R.R.	[illegible]	3	2	[illegible]	[illegible]	[illegible]	15	1,000,000
[illegible] R.R.	—	—	—	—	—	[illegible]	[illegible]	100,[illegible]
[illegible] R.R.	136,[illegible]	3	3	2		[illegible]	16	415,041
[illegible] Lackawanna and Western R.R.	1,[illegible],431	77	[illegible]	15	4,[illegible]	170	113	[illegible]
Lackawanna and Bloomsburg R.R.	[illegible]	[illegible]	[illegible]	[illegible]	1,[illegible]	100	80	3,[illegible]
[illegible] and Hudson Canal Co.'s R.R.	926,421	4	[illegible]	6	1,[illegible]	65	[illegible]	1,[illegible]
Pennsylvania Coal Co.'s R.R.	[illegible],792		[illegible]	2	2,000	100	47	2,000,000
[illegible] R.R.	—	—	—	—	—	5	10	80,000
						1,531½	856	$70,100,036

TABLE OF CANALS EMPLOYED IN THE COAL TRADE.

NAMES OF CANALS.	TRANSPORTATION. Anthracite—tons.	Bituminous—tons.	Other Freight—tons.	Breadths—feet.	Depths—feet.	No. of Boats running.	No. of Locks.	Amount of Lockage—feet.	Length of Line—miles.	Cost.
Schuylkill Navigation	1,120,560	5,924	245,046	40	6	3,000	71	618	108	$12,061,920
Lehigh Coal and Navigation	847,123	....	206,040	75	6	1,114	53	375	48	4,445,000
Delaware Division	500,000	....	114,420	44	6	1,000	32	165	60	2,435,350
Delaware and Hudson	1,574,423	774	100,000	48	6	1,033	109	1028	108	6,252,000
North Branch	156,103	57,588	42,403	40	4	....	82	244	105	853,066
Wyoming Valley	573,146	617	67,491	40	4½	1,200	11	90	64	2,000,000
Susquehanna and Tide-Water	284,428	9,898	247,385	50	5	600	33	233	45	4,671,000
Union Canal	29,847	6,301	163,125	43	4½	....	104	500	77	5,787,000
West Branch	520,685	862	244,572	40	4	....	35	175	117	*1,000,000
Pennsylvania Canal	650,747	32,242	441,555	50	5	1,120	145	653	173	*1,000,000
									905	$40,503,365

The length of locomotive track, including sidelings, used exclusively as coal roads, is 1,531¼ miles, and the length of the main lines 856 miles.

The length of mining tracks inside and outside of the mines, including tramways, leading from mines to shipping points, such as the Lehigh gravity roads, &c., is 780 miles.

MINING TRACK INSIDE AND OUTSIDE OF MINES.

Name of Region.	Inside of Mines. Miles.	Outside of Mines. Miles.	Total Miles.
Schuylkill Region	200	44	244
Wyoming and Lackawanna Region	251	52	303
Lehigh Regions	67	56	123
Mahanoy Region	54	22	76
Shamokin Region	24	10	34
Total miles	596	184	780

* Cost to present owners.

PLANE ENGINES USED IN TRANSPORTING COAL.

Localities and Names.	No. of Engines.	Power of Engines.
Delaware and Hudson Canal Co's Planes	24	2,165
Pennsylvania Coal Co's Planes ....(estimated)	23	2,000
Lehigh Coal and Navigation Co's Planes	8	1,100
Lehigh and Susquehanna Railroad Planes	3	390
Mahanoy and Broad Mountain Railroad Planes ...	2	500
Mine Hill and Mahanoy Planes..................	2	392
	62	6,547
Engines used in mining Coal at Mines	792	41,453
Total Horse-power.................	854	48,000

HOME AND COLLIERY CONSUMPTION.

We gave the amount of coal consumed by our anthracite blast furnaces under the Statistics of Iron. This is included in the shipments, but the amount of coal used at the mines for steam, ventilation and other purposes, can only be estimated, since they do not appear in the tables of the trade, and are not estimated in the colliery productions. Much of the coal consumed by the colliery hands, and in fact the home consumption generally, are either obtained gratuitously from the mines, or are the production of very small operations in the outcrops of coal-seams or abandoned mines, which are not noticed in the statistical returns.

The theoretical value of coal, if all its carbon is properly consumed, and its caloric utilized, is one horse-power from one-tenth of a pound of coal. But our very best steam engines give a horse-power from the combustion of two pounds of coal per hour, and it may be estimated as pretty good economy if we obtain a horse-power from the consumption of four pounds of coal per hour. In the coal regions not less than six pounds of coal are consumed per hour for every horse-power while in operation, or seven tons per one hundred horse-power in twenty-four hours.

The number of steam colliery engines are 792, and the power 41,453 horses, which, at a consumption of seven tons per 100 horse-power in twenty-four hours, will require 870,813 tons per annum for the colliery engines alone. To this may be added an equal amount for the ventilating furnace fires, smiths' works, miners' uses, &c., &c. We are safe, however, in stating that not less than 1,500,000 tons of coal are annually used for home and colliery consumption in the Anthracite Regions, which do not appear in the published returns of the coal trade.

SECTION III.

LEHIGH COAL BASINS.

No. 1.—(See Map.)

BUCK MOUNTAIN COAL CO.

Clifton and Black Creek Basin mines: Four collieries, all on "Buck Mountain" vein, below water level; steam-power, 385 horse; capacity, 125,000 tons per annum; production in 1864, 78,534 tons; in 1865, 88,404 tons.

No. 2.

SHARP, WIESS & CO.

Eckley mines, at Eckley, in Big Black Creek Basin, on Mammoth vein, below water level; steam-power, 275 horse; capacity, 125,000 tons per annum; production in 1864, 109,349; in 1865, 105,411 tons.

No. 3.

GEO. B. MARKLE & CO.

Jeddo mines, at Jeddo, in Big Black Creek Basin: Three slopes on Mammoth and one in Buck Mountain vein; steam-power, 600 horse; production in 1864, 153,563 tons; in 1865, 143,897 tons.

No. 4.

EBERVALE COAL COMPANY.

Ebervale mines, at Ebervale, in Big Black Creek Basin: Three slopes on Mammoth; production in 1864, 52,137 tons; in 1865, 54,785 tons.

No. 5.

HARLEIGH COAL COMPANY.

Harleigh mines, at Harleigh, in Big Black Creek Basin: Two slopes on Mammoth; steam-power, 140 horse; capacity, 100,000 tons per annum; production in 1864, 60,796 tons; in 1865, 65,455 tons.

No. 6.

STOUT COAL COMPANY.

Milnesville mines, at Milnesville, in Little Black Creek Basin: Three slopes on Mammoth and Buck Mountain; steam-power, 195 horse; capacity, 100,000 tons per annum; production in 1864, 61,214; in 1865, 56,741 tons.

No. 7.

PACKER, LINDERMAN & CO.

Stockton mines, at Stockton, Hazleton Basin: Four slopes on Mammoth; steam-power, 670 horse; capacity, 1,000 tons per day; production in 1864, 143,090 tons; in 1865, 123,615 tons.

No. 8.

A. PARDEE & CO.

Hazleton mines, Diamond mines, Laurel Hill mines, Cranberry mines, Crystal Ridge mines No. 1, and Crystal Ridge mines No. 2: Eight collieries below water level on Mammoth bed; steam-power, 1,032 horse; capacity, 10,000 tons per week; production in 1864, 210,907 tons; in 1865, 170,718 tons.

No. 9.

TAGGART, HALSEY & CO.

Mount Pleasant mines, Hazleton Basin, west of Hazleton: Two slopes on Mammoth; production in 1864, 39,391 tons; in 1865, 28,426 tons.

No. 10.

ASHBURTON COAL COMPANY.

Ashburton mines, Hazleton Basin, four miles west of Hazleton: New place in course of development; no shipments; on Wharton (Skidmore) and other white ash seams; steam-power, 150 horse.

No. 11.

WILLIAM T. CARTER & SON.

Coleraine mines, in Beaver Meadow Basin: Three slopes on Mammoth; steam-power, 275 horse; capacity, 2,000 tons per week; production in 1864, 49,181 tons; in 1865, 54,735 tons.

Figure 193.

HONEY BROOK COAL BASINS.

No. 15—See Map.

HONEY BROOK COAL COMPANY.

Capital, $3,000,000.

The celebrated Honey Brook and Audenried mines are located in Carbon, Luzerne and Schuylkill counties, (see Map of the Anthracite fields,) and in the western, and perhaps the most productive portion of the first Lehigh coal field, generally known as the Beaver Meadow Basin.

Reference is made to the Honey Brook Basins on page 192 and 193, where some doubt is expressed, though not prejudicial, as to the number of coal seams and the depth of the basins; but above we present an accurate transverse section of these basins.

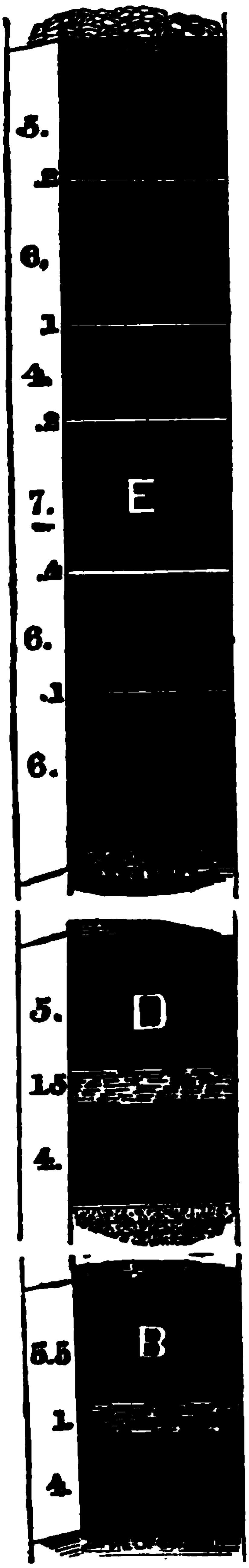
It will be noticed, and demonstrated by the accompanying section, on the next page, that the Mammoth bed is here in its best condition, and that all the lower seams, except A, are in good condition. One very singular feature of these basins is the existence of the lower bed, B, on the *red-shale*, and the conglomerate between the beds.

The lower veins, however, are not as large here as in a few other parts of the Lehigh Regions, but the Mammoth is in its maximum size, and presents a magnificent bed of nearly pure coal, from thirty-five to forty feet in thickness.

The Lehigh coals enjoy a higher reputation generally than any other coal sent to market, and the production of the Honey Brook mines is the *very best Lehigh*.

For all purposes in which Anthracite fuel is available, this coal is a superior article, from its preëminent purity and freedom from *sulphur* and *slate.*

Figure 194.



Coal Sections at Honey Brook.

The accompanying section of the Mammoth presents six solid beaches of coal that cannot be equalled in the Lehigh Region; while both the Wharton, D, (Skidmore,) and the Buck Mountain, B, as represented, are fine workable seams.

There are three large collieries at Honey Brook; one known as the "Audenried shaft" in the right, or North basin, and two in the left, (slopes,) or South basin, as represented. They are all provided with powerful machinery for pumping water, and hoisting and preparing coal—the aggregate power is about 1,000 horse. The present capacity of the mines is about 300,000 tons per annum, if worked up to their ability, while the property is capable of producing double the amount for fifty years to come. About 150,000 tons were produced during 1864, and 129,000 tons in 1865. The great drawback to the production has been the want of transportation from the mines to the markets, which has been suffered in common with all the Lehigh shippers. An opportunity exists, however, to connect these mines by a short and favorable road with the Little Schuylkill and Reading Railroad, and open eventually a new outlet to both Philadelphia and New York.

The Honey Brook Estate consists of 1,156 acres of land, and the amount of coal which it contains has been estimated at from 30,000,000 to 50,000,000 tons. The three collieries now in operation are fully equal to the production of 1,000 tons per day, while there is ample room for three additional collieries of equal or greater capacity. The total capacity of the property may therefore be stated at 500,000 tons per annum.

The mining villages of Audenried, Honey Brook and Springville, which are located on this property, contain

nearly two hundred houses, while Audenried, the principal village, has a fine hotel, and is one of the prettiest villages in the Coal Regions.

PRESIDENT:

J. B. McCREARY.

TREASURER:

DAVIS PEARSON.

SECRETARY:

S. McHENRY.

DIRECTORS:

J. B. McCREARY, | DAVIS PEARSON,
LEWIS AUDENRIED, | GEORGE H. MEYERS,
THOMAS A. REEVES.

No. 12.

GERMAN PENNSYLVANIA COAL COMPANY.

Tresckow: Two collieries in Beaver Meadow Basin; three slopes; one on Wharton (Skidmore) and two on Mammoth; steam-power, 420 horse; capacity, 100,000 tons per annum; production in 1864, 78,402 tons; in 1865, 67,448 tons.

No. 13.

SPRING MOUNTAIN COAL CO.

Jeansville mines, in Beaver Meadow Basin: Five slopes on Mammoth; steam-power, 636 horse; capacity, 150,000 tons per annum; production in 1864, 102,881 tons; in 1865, 97,130 tons.

No. 14.

THOMAS HULL & CO.

Smith's Spring Mountain mines, in Beaver Meadow Basin, west of Jeansville: Three slopes on Mammoth; capacity, 100,000 tons per annum; production in 1864, 53,110 tons; in 1865, 66,248 tons.

No. 16.

McAULEY MOUNTAIN COAL CO.

In McAuley Mountain Basin, which is the most western and limited of the Lehigh Coal Basins. Buck Mountain vein, production in 1865, 546 tons.

Figure 196.

MIDDLE COAL FIELD—SHAMOKIN REGION.

No. 2.

WILLIAM MONTELIUS.

Stuartsville colliery, near Mount Carmel, on land of Locust Mountain Coal and Iron Company: Mammoth vein, above and below water level; average capacity, 50,000 tons per annum; production in 1865, 23,251 tons; steam-power, 60 horse.

No. 3.

WM. F. PATTERSON & CO.

Coal Mountain colliery; location Mount Carmel, on lands of Susquehanna Coal and Coal Mountain Company: Mammoth vein, below water level; production in 1865, 8,963 tons; steam-power, 130 horse.

No. 4.

HOOVER & YARNALL.

Isaac Taylor colliery, near Mt. Carmel, on Mammoth: Production in 1865, 4,596.

No. 5.

SAMUEL JOHNS & SONS.

Green Mountain colliery, near Mount Carmel, on lands of Green Mountain Coal Company: Capacity, 30,000 tons per annum; Mammoth vein above water level; steam-power, 40 horse; production in 1865, 14,732 tons.

No. 6.

J. H. DEWEES.

Excelsior colliery, on Fulton Coal Co. lands, above water level, on the Mammoth: Steam-power, 30 horse; capacity, 50,000 tons per annum; production in 1865, 18,572 tons.

No. 7.

J. B. DOUTY & CO.

Crittenden colliery, near Locust Gap, on Fulton Improvement Coal Company lands, above water level, on Mammoth or Twin veins: Steam-power, 25 horse; capacity, 30,000 tons per annum; production in 1865, 13,919 tons.

No. 8.

C. F. NORTON & CO.

Enterprise colliery, near Locust Gap, on Fulton Improvement Company land, above water level, on Mammoth vein: Steam-power, 25 horse; capacity, 30,000 tons per annum; production in 1865, 11,372 tons.

No. 9.

SHAMOKIN COAL COMPANY.

Lancaster colliery, on the lands of Shamokin Valley and Pottsville Railroad Company, on Mammoth vein: Production in 1865, 43,751 tons.

No. 10.

J. H. DEWEES & BROTHER.

Lambert colliery, on land of New York and Middle Coal-field Company, below water level, Orchard vein, Red-ash coal: Steam-power, 60 horse; capacity, 5,000 tons per month; production in 1865, 16,528 tons.

No. 11.

BURNSIDE COAL AND IRON CO.

Luke Fidler colliery: Red-ash coal; production in 1865, 12,394 tons.

No. 12.

DOUTY & PENNINGTON.

Near Shamokin, on land of B. A. G. Fuller, below water level: Steam-power, 80 horse; capacity, 50,000 tons per annum; new colliery in course of development.

No. 13.

J. B. DOUTY, Agent.

Henry Clay colliery, near Shamokin, on land of B. A. G. Fuller, above water level, on Mammoth vein: Steam-power, 30 horse; capacity, 60,000 tons per annum; production in 1865, 32,523 tons.

No. 14.

MAY, PATTERSON & BROTHER.

Buck Ridge colliery, near Shamokin, on lands of Johnston & Ranshaw, above water level, on Mammoth vein: Steam-power, 30 horse; capacity, 100,000 tons per annum; production in 1865, 41,522 tons.

No. 15.

BIRD COAL AND IRON COMPANY.

Big Mountain colliery, near Shamokin, on lands of Big Mountain Improvement Company, above water level, Mammoth or Twin veins: Steam-power, 30 horse; capacity, 500 tons per day; production in 1865, 40,294 tons.

No. 16.

JOHN HAAS & CO.

Cameron colliery, below Shamokin, on lands of William Cameron & Co., above water level, Buck Mountain and other veins; steam-power, 20 horse; capacity, 100,000 tons per annum; production in 1865, 66,114 tons.

No. 17.

S. BITTENBENDER & CO.

Burnside colliery, near Shamokin, on lands of Big Mountain Improvement Company, above water level, on Mammoth and Primrose veins: Steam-power, 60 horse; capacity, 50,000 tons per annum; production in 1865, 29,158 tons.

No. 18.

SHAMOKIN AND BEAR VALLEY COAL COMPANY.

Bear Valley colliery, Carbon Run, on lands of Shamokin and Bear Valley Coal Company, above water level, on Mammoth or Twin veins: Steam-power, 30 horse; capacity, 70,000 tons per annum; production in 1865, 36,539 tons.

No. 19.

BALLARD & CO.

Continental colliery, on lands of Fulton Improvement Company, above water level, on Mammoth and Overlying veins: Steam-power, 45 horse; capacity, 50,000 tons per annum; production in 1865, 4,136 tons.

No. 20.

TREVERTON COAL COMPANY,

At Treverton, on land of Treverton Coal Company, above water level, on Buck Mountain and other lower veins; production in 1865, 27,095.

No. 21.

SUTTON & HENRY.

Dan Webster colliery: New enterprise in course of development; production in 1865, 10 tons.

MAHANOY REGION—MIDDLE COAL FIELD.

No. 1.

T. F. PATTERSON & CO.

Above Mahanoy City, on Delano lands; south dips of Skidmore and Buck Mountain veins, above water level; Steam-power, 20 horse; new place.

No. 2.

GORMAN & WINTERSTEEN.

Above Mahanoy City, on Delano lands; north dips of Skidmore and Buck Mountain veins, above water level; new place.

No. 3.

THOMAS GORMAN.

(Now Hartford Associated Coal Co.)

Thomas Gorman's colliery, near Mahanoy City, on Kear & Patterson's lands, above water level, on Buck Mountain vein: Steam-power, 20 horse; capacity, 300 tons per day; production in 1865, 26,918 tons.

No. 4.

EAST MAHANOY COAL CO.

Near Mahanoy City, on Delano lands, above water level, on Skidmore and Buck Mountain vein: Production in 1865, 13,683 tons.

No. 5.

HILL & HARRIS.

Mahanoy City colliery, on lands of Dundas, Troutman & Biddle, on Skidmore, Mammoth and Primrose veins, above water level: Steam-power, 30 horse; capacity, 5,000 tons per month; production, 40,144 tons in 1865.

No. 6.

ST. NICHOLAS COAL COMPANY.

St. Nicholas colliery, below Mahanoy City, on lands of Dundas, Troutman & Biddle, above water level, on Mammoth and Buck Mountain veins: Steam-power, 30 horse; capacity, 125,000 tons per annum; production in 1865, 90,818 tons.

No. 7.

WIGGAN & TREIBLES.

Near St. Nicholas, on lands of Dundas, Troutman & Biddle, above water level, on Mammoth and other veins: production, 44,952 tons in 1865.

No. 8.

ALTHOUSE & FOCHT.

Boston Run colliery, on lands of Kear & Patterson, above water level, on Mammoth, Skidmore and Buck Mountain veins: production in 1865, 40,870 tons.

No. 9.

GEORGE W. COLE.

Tunnel Ridge colliery, on lands of Dundas, Troutman & Biddle, above water level, on Mammoth, Primrose and Skidmore veins: Steam-power, 60 horse; production in 1865, 39,524 tons.

No. 10.

RATHBUN, STEARNS & CO.

(Now Associate Coal Company.)

Rathbun colliery, near Mahony City, on lands of Kear & Patterson, above water level, on Primrose and Mammoth veins: Capacity, 50,000 tons per annum; production in 1865, 28,427 tons.

No. 11.

MAMMOTH VEIN CONSOLIDATED COAL COMPANY.

Mahanoy Valley colliery, above Mahanoy planes. Tunnel, above water level, on Primrose and Mammoth veins: Steam-power, 30 horse; production in 1865, from four collieries, including "Locust Mt.," and the "Locust Gap" collieries, 113,209 tons.

(See description in Schuylkill Region.)

No. 12.

GILBERTON COAL COMPANY.

Gilberton colliery, Mahanoy Valley, on lands of John Gilbert, below water level, on Mammoth vein: Steam-power, 250 horse; capacity, 100,000 tons per annum; production in 1865, 35,259 tons.

No. 13.

W. H. SHEAFER.

Old Tunnel, on the Girard Estate, above water level, on Skidmore; production in 1865, 5,973 tons.

No. 15.

C. GARRETSON.

Girard colliery, below planes, on Mammoth and lower veins; production in 1865, 31,784.

No. 16.

DENGLER & ROBINSON.

(Now Boston and Mahanoy Coal Co.)

Opposite Mahanoy planes, slope on Mammoth; production in 1865, 10,215 tons.

No. 17.

CONNER & CO.

Locust spring colliery, on the Girard Estate, above water level, on Mammoth and Primrose veins: Steam-power, 15 horse; capacity, 200 tons per day.

(See Conner & Patterson.)

No. 19.

GEO. W. HUNTZINGER & CO.

Colorado colliery, on Girard Estate, in Shenandoah Valley, below Shenandoah City, above water level, on Mammoth vein: Steam-power, 30 horse; capacity, 75,000 tons per annum; production in 1865, 22,431 tons.

No. 20.

S. E. GRISCOM & CO.

In Shenandoah Valley, two miles below Shenandoah City, above water level, on Orchards, Primrose, Mammoth, and Lower beds: Steam-power, 40 horse; capacity, 500 tons per day; production in 1865, 9,121 tons.

No. 21.

GIRARD MUTUAL COAL CO.

Shenandoah colliery, on Girard Estate, in Shenandoah Valley, below Shenandoah City, above water level, Mammoth vein: Steam-power, 30 horse; capacity, 75,000 tons per annum; production in 1865, 36,900 tons.

No. 22.

A. C. MILLER & CO.

Shenandoah City colliery, (P. W. Sheafer, agent for land-owners)—above water level, on Buck Mountain, Skidmore and Mammoth: Steam-power, 75 horse; capacity, 100,000 tons; production in 1865, 74,902 tons.

No. 23.

KNICKERBOCKER COAL CO.

(Late Fowler & Huhn.)

Shenandoah colliery, above Shenandoah City, on lands of Dundas, Troutman & Biddle, above water level, on Buck Mountain, Skidmore, Mammoth and Primrose veins: Steam-power, 50 horse; capacity, 100,000 tons per annum; production in 1865, 27,602 tons.

No. 24.

SUFFOLK COAL COMPANY.

Suffolk colliery, near St. Nicholas, on lands of Dundas, Troutman & Biddle, above water level, on Buck Mountain, Skidmore, Mammoth and Primrose veins: Steam-power, 30 horse; capacity, 100,000 tons per annum; production in 1865, 39,083 tons.

No. 25.

GLENVILLE COAL COMPANY.

Glenville colliery, near the McNeal Coal Company, on lands of Dundas, Troutman & Biddle, above water level, on Buck Mountain, Skidmore, Mammoth and Primrose veins: Steam-power, 40 horse; capacity, 100,000 tons per annum; production in 1865, 58,945 tons.

Figure 197.

No. 19—See Map.

GIRARDSVILLE COLLIERY.†

This colliery is located on the Girard Estate, or Philadelphia city lands, near Girardsville, and on the southern dips of the Mahanoy basin, where the coal-beds commence to overlap the Locust Ridge into the Shenandoah Valley. The Mammoth bed exists here in its best condition, about 25 feet thick, with a breast of 240 feet above water level, and a "run" of two miles. The Skidmore is also in its best size and character 16 feet thick, with a breast above water level of 2,700 feet, and the same "run" as the Mammoth. The next underlying bed, the Buck Mountain, is reported as not opened, its average size is 16 feet. Above the Mammoth are found the Mahanoy (Primrose) and the Orchards, all in good condition, the latter being red-ash seams.

The mines of the Girardsville colliery is above water level, and the amount of coal still available, without sloping, will last for many years to come.

The capacity of this colliery is fully 100,000 tons per annum, but, like others, suffer for want of transportation. The production in 1865 was 47,156 tons, and including the Locust Spring colliery, of Conner & Co., 65,532 tons. During 1864 these two collieries produced 81,097 tons, yet the mining facilities in 1865 were greater than 1864.

The coal produced from these collieries is the celebrated "Locust Mountain," and, like all or most of the coal obtained from this famous Anthracite range, is splendid in appearance, and almost a pure carbon. It was used extensively by our Government during the war for steam purposes on board the blockaders along the southern coast. It burns freely, produces no smoke, and leaves a small residue of ash, without embers or clinkers. We consider this colliery one of the best in the Anthracite regions. The present proprietor is

Col. JAMES J. CONNER,
Of Pottsville.

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* This firm has been dissolved, by the withdrawal of Joseph S. Patterson, since this illustration was made.

† The above illustration is not designed as a representation of this colliery, but the different operations of mining coal.

THE PRESTON MINES, 34.

Figure 198.

TRANSVERSE SECTION OF THE MAHANOY COAL-BASINS AT PRESTON.

DESCRIPTION.—Figure 198 is a transverse section from the Locust to the Mahanoy mountains, on the Preston Estate, a little to the west of Girardsville. The Mahanoy mountain is on the left, and the Locust on the right of the section. The observer looks west: *a a* are drifts on the Mammoth and Mahanoy, and supply the Preston colliery, No. 1, the breaker of which is located at *d*; *b* is the Preston colliery, No. 2, which is supplied by slope *c*, on the Mammoth, and two drifts on the Buck Mountain; *e* is a water-level tunnel, which drains the slope *c*; *g* is a small basin, on which the Folkton colliery is located. This basin terminates a short distance west, and the workings of the Folkton colliery, passing around the west end of the middle basin, enter the left basin under *h*.

The Preston colliery, No. 4, *o*, is located about one mile west of the Folkton, and is supplied by tunnel *h*, which cuts the lower red-ash seams, the Mammoth and all the white-ash beds. The Folkton colliery is not located on the section, but the tunnel *i*, apparently under the No. 4 colliery, though nearly one mile east, drains the slope of the Folkton. The letters A, B, C, D, E, F, G, denote the white-ash beds, and H, I, J and K the red-ash seams.

THE PRESTON COAL AND IMPROVEMENT COMPANY.

This company was incorporated by special act of the Pennsylvania Legislature, March 16th, 1864. The Preston Estate consists of 2,500 acres of land, of which 2,000 are within the coal measures, and in the centre of the Mahanoy Region of the middle coal-field. The lands of this company extend across the field, and contain two deep and extensive basins of coal to the west, and three basins to the east, as above represented. All the coal-beds of this region exist on the property, and all the beds of the Anthracite coal-fields, except the three upper ones in the Pottsville district. Our section presents four red-ash seams, the two Orchards, the Diamond or Daddow, and the Clinton, with an aggregate thickness of from 20 to 30 feet of coal. The white-ash beds are, the Mahanoy, or G, 12 feet thick; the Holmes, F, or "Seven Feet," 7 feet thick; the Mammoth, E, from 25 to 30 feet; the Skidmore, D, 10 feet; the Buck Mountain, B, 16 feet, and two small seams, C and A, from 2 to 5 feet respectively. The aggregate thickness of the white-ash beds range from 70 to 80 feet, and the total thickness is 100 feet of available coal on this property.

A large amount of this coal lies above water level, or the natural drainage, and this advantage has been made available by the company; their mines are all drained by gangways and tunnels, thus saving a large expenditure for pumping machinery, and the constant expense of keeping it in operation. These are large and important items in mining economy.

There are now four collieries on the Preston Estate, with ample room for, at least, two more. Those in operation are named and described in connection with the transverse section. The Preston colliery, No. 4, is about one mile west of the Folkton,

on the Orchards, (red-ash,) Mahanoy, Seven Feet, Mammoth and all the lower beds, by tunnel in the Mahanoy mountain. The "breasting" on the Mammoth and lower seams is over 900 feet on the face of the mountain, consequently two "counter levels" will be required to obtain the coal. This will give *six gangways* on each coal-bed, or eighteen on the three principal seams, while the "run" is two miles east and west. One thousand tons of coal per day can be obtained from this colliery with ease, and the breaker capacity is equal to the mine production. The Preston, No. 4 coal-breaker is, perhaps, the largest one in the Anthracite Regions in dimensions or capacity, and is provided with a double set of rolls for the purpose of preparing both white and red-ash coal.

Fig. 180.

The construction and the machinery of this great coal-preparing establishment reflects credit on the company's superintendent, Mr. Koerner, and the mechanics, Messrs. Wren, of the Washington iron works, Pottsville.

When fully developed, this colliery is capable of producing 1,000 tons of coal per day from above water-level, for many years to come. A glance at the accompanying sections of the three principal coal-beds, G, E and B, will be sufficient to demonstrate the purity of the coal and the absence of slate in the seams. G is frequently found 12 feet thick in one solid bench of splendid coal, while both E and B have only two small partings each. The coal of Mahanoy region is generally excellent in quality and prepossessing in appearance; and, we may state, without hesitation, that the Preston coals are equal to the best "Locust Mountain" or Mahanoy coal. The steam capacity of the four collieries on this estate is only 370 horse-power, since no pumping machinery is required, yet their capacity is from 400,000 to 500,000 tons per annum. The production during 1865 was only 86,577 tons, but the frequent suspensions of last year, and the inadequate transportation, prevented a greater tonnage. Only two collieries, the Preston, Nos. 1 and 2, and the Folkton, for a short time only, were in operation. The No. 4 colliery is scarcely yet completed, but will be ready for operation for the Spring business.

The facilities for transportation from these collieries to the markets are equal to any in the valley. There are three outlets to Philadelphia now open, and a fourth, to New York, in course of construction, while a fifth, to both Philadelphia and New York, is under consideration. We may say in a word, that the Preston Coal and Improvement Company cannot fail to be one of the most successful in the Anthracite regions, under careful and judicious management.

The officers and directors of the company are:

BEDS G, E AND B, AT PRESTON.

President—HON. HENRY D. MOORE. *Vice-President*—GEO. J. FOREST.

Secretary and Treasurer—H. P. RUTTER.

Directors—HENRY D. MOORE. WM. G. MOORHEAD. GEO. J. FOREST. WM. HUNTER, JUN. J. HICKS CONRAD.

No. 26.

MCNEAL COAL AND IRON CO.

Yatesville colliery, on their own lands, about 600 acres, on Primrose, Mammoth and all underlying veins: Three drifts, all above water level; steam-power, 50 horse; capacity, 125,000 tons per annum; production in 1865, 58,119 tons.

No. 27.

COAL RUN COAL COMPANY.

Production in 1865, 12,386 tons.

No. 28.

J. & E. S. SILLIMAN.

Production in 1865, 38,593 tons.

No. 29.

A. LAWTON & CO.

(Now Glendon Coal Company.)

Near Mahanoy City, above water level, on Mammoth and Skidmore: Steam-power, 70 horse; production in 1865, 37,619 tons.

No. 30.

SHOEMAKER & CO.

(Now Mahanoy Coal Company.)

Mammoth colliery, on Delano Land Company, above water level, on Buck Mountain, Gamma, Skidmore, Mammoth and Primrose: Steam-power, 25 horse; capacity, 50,000 tons per annum; production in 1865, 16,154 tons.

No. 31.

ALTER & FOCHT.

East Mahanoy colliery, on lands of Delano Land Company, above water level, on Buck Mountain, Gamma and Skidmore: Steam-power, 30 horse; capacity, 75,000 tons per annum; production in 1865, 35,348 tons.

No. 32.

MEYER & LAMAN.

(Now Mount Etna Coal Company.)

North Mahanoy colliery, on lands of Delano Land Company, below water level, on Buck Mountain vein: Steam-power, 180 horse; production in 1865

No. 33.

J. & O. O. BOWMAN.

Delano colliery, on lands of Delano Land Company, above water level, on Skidmore vein: Steam-power, 20 horse; capacity, 70,000 tons per annum; production in 1865, 34,258 tons.

No. 35.

SCHALL & DONAHOE.

On Big Mine Run, Buck Mountain vein: Production in 1865, 17,957 tons.

No. 36.

BAST & PEARSON.

Two collieries on Big Mine Run: One in operation in 1865, on Mammoth and other white-ash veins; steam-power, 145 horse; capacity, 150,000 tons per annum; production in 1865, 89,087 tons.

(See Locust Mountain Coal and Iron Company, page 743.)

No. 37.

UNION COAL COMPANY.

Formerly Keystone and Tunnel collieries. "Tunnel," recently disposed of to the Schuylkill Mutual Coal Company. For full report of the Keystone colliery see No. 40, Wyoming Region: Production of Tunnel and Keystone collieries in 1865, 87,337 tons.

No. 39.

REPPLIER & MOODIE.

Locust Run colliery, on lands of Locust Mountain Coal and Iron Company. Mammoth and other white-ash veins: Steam-power, 230 horse; capacity, 125,000 tons per annum; production in 1865, 86,5[illegible] tons.

No. 40.

J. H. W. PAGE.

William Wadleigh, Agent.

Conner & Patterson's old colliery, near Ashland, on Mammoth: Production in 1865, 20,700 tons.

No. 41.

JOHN ANDERSON & CO.

Production in 1865, 36,332 tons.

No. 42.

R. GORRELL & CO.

Hazel Dell colliery, on lands of Locust Mountain Coal and Iron Company, Mammoth and other white-ash veins: Steam-power, 185 horse; production in 1865, 86,311 tons.

No. 43.

J. M. FRECK & CO.

Centralia colliery, on lands of Locust Mountain Coal and Iron Company, Mammoth and other veins: Production in 1865, 68,438 tons.

No. 44.

CONTINENTAL COAL COMPANY.

(Formerly Carter, Shoener & Co.)

New operation north of Locust Ridge and east of Centralia, now in course of development on lower veins.

No. 45.

S. M. HEATON & CO.

On Raven's Run: New colliery now in course of development.

No. 47.

BLACK DIAMOND COAL AND IRON COMPANY.

Locust Summit and Locust Creek collieries, at Locust Gap, on the lands of the Locust Summit Improvement Company and A. McIntire, Esq., on Mammoth and other white-ash veins, above and bebelow water level: Steam-power, 100 horse; capacity, 100,000 tons per annum; production in 1865, 55,402 tons.

MAMMOTH VEIN CONSOLIDATED COAL COMPANY.

The Mammoth Vein Consolidated Coal Company have four collieries in the Mahanoy Region. The "Mahanoy Valley," above the planes; the "Locust Mountain," near Locust Dale; the "Locust Gap" and "A. S. Wolf," at Locust Gap: Production in 1865, 113,209 tons. (For further description see No. 8, Schuylkill Region.)

LOCUST MOUNTAIN COAL AND IRON COMPANY.*

This company own 4,000 acres of coal land, but are not miners and shippers of coal. They lease to the following Operators:

	Tons
R. Gorrell & Co., Hazel Dell colliery	86,651
Bast & Pearson, Big Min Run colliery	86,493
Repplier & Moodie, Locust Run colliery	84,293
J. M. Freck & Co., Centralia colliery	68,667
William Montelius, Stuartsville colliery	23,231
Mammoth Vein Central Coal Co. Locust Mountain colliery	17,662
Total	366,997

Steam-power, 20 engines; 935 horse.

No. 48.

LEE, GRANT & CO.

Above Shenandoah City, in the south or inverted Shenandoah basin, above water level, on Buck Mountain vein: New colliery, now in course of development; production in 1865, 4,168 tons.

No. 49.

J. B. REBER & CO.

Near Shenandoah City, in North Shenandoah basin: New colliery in course of development; production in 1865, 2,185 tons.

* There is a slight difference between the amounts furnished us by this company and those obtained from the shipping returns.

PIONEER COLLIERY, No. 38.

Figure 209.

BANCROFT, LEWIS & CO.

We give above an illustration of the Pioneer Colliery. The engraving does not do justice to the picturesque effect of this large mining establishment, situated, as it is, on the face of a hill that may almost be termed a mountain; with its machinery and buildings elevated several hundred feet, the railroad at the shutes.

In operation, the whole scene is animated, and presents a business-like appearance.

A large amount of coal has been annually sent from these mines since the first development of the Mahanoy region; and, as the name signifies, this is the pioneer colliery of that now famous and productive valley. Most of the coal from this celebrated colliery has been mined from above water level, and much still remains to be mined by drift, with the immense bed of the 30 feet Mammoth, almost un-

touched below water-level. The first "lift" of 110 yards has only yet been sunk, leaving four or five lifts—or perhaps more—of equal depth, still to be opened.

There are, at present, in operation one slope and two drift above water-level. The steam machinery of this colliery consists of one Cornish pumping-engine of 500 horse-power; one engine. of 100 horse-power, for hoisting coal from below water-level; one plane-engine, of 30 horse-power, for hoisting coal from the lower drift; one plane-engine, of 40 horse-power for hoisting dirt up a plane of 500 feet long, at an angle of 30°; one fan-engine, of 10 horse-power, for ventilating purposes, and one of 10 horse-power, for supplying the boilers with water; with one breaker-engine, of 30 horse-power. The whole steam-power aggregating 760 horse-power.

A novel arrangement is used at this colliery for hoisting coal in the slope which answers an admirable purpose as a self-acting dump, and dispenses with the heavy cages now generally made use of. For deep and steep slopes, and for shafts, the principle here adopted, cannot fail to act with great economy, in saving both time and power. Mine cars cannot be brought up *steep* slopes and shafts, except on cages, which are generally very heavy. This arrangement consists of a peculiar car constructed to operate in the slope, and receives the coal from the mine cars at the bottom of the slope. At the top the coal is discharged automatically, and the car is ready to return without loss of time. We understand this improvement has been patented by Jos. W. Bancroft, Esq.

The capacity of this colliery has been stated at 750 tons per day, but the facilities for transportation have never been equal to the production. During 1864, 56,000 tons were shipped, and in 1865, 63,000 tons. The coal produced enjoys a high reputation in market. and from the character of the Mammoth, and the style of the improvements, we should judge that the coal may be mined with much economy.

THE ASHLAND ESTATE.

The Ashland Estate, belonging to the Messrs. Brock, Grant, and others, covers a large tract of valuable coal lands in the vicinity of Ashland. The PIONEER, Tunnel, Keystone, and "Page's Locust Run" collieries are on this Estate. The total production of this Estate in 1865 was 170,124 tons.

Figure 301.

LOCUSTDALE* COAL COMPANY.

Figure 202.

TRANSVERSE SECTION AT LOCUSTDALE.

The above transverse section represents the coal basins in the vicinity of Locustdale. The property owned by the Locustdale Coal Company extends from the centre of the deep left basin to, and inclusive of, the middle basins on the right of the Bear ridge, anticlinal. It will be noticed that all the important coal seams of the anthracite fields are here represented, from A, in the conglomerate, to and inclusive of H and I, or the Orchards, with an aggregate thickness of from 100 to 125 feet of available coal.

The position or conformation of these deep and extensive basins of coal are extremely favorable for mining operations, since all the coal on the property can be obtained, if desirable, through one slope, sunk—as the present one is on the Mammoth—by tunnels north and south. The south dip of the coal beds in the deep basin, on the left, range from 45° to 70°; consequently the tunnel distance from seam to seam will be limited—the tunnel distance decreases as the dips increase and *vice versa*. It will also be noticed that the north dips of the seams are inverted in the middle basins and pitch in conformity, nearly, with the south dips; this naturally decreases the tunnel distance from one basin to the other and renders the coal in the middle basin available to the present slope on the Mammoth.

The estate of the Locustdale Coal Company embraces 1243 acres of coal land, running east and west on the south and middle basins, as before described. The "run" of the gangways on the seams may be nearly three miles—(that is, the "run" on the "strike" of the veins, in mining phrase)—and the plane of the coal, descending to the centre of the deep basin, is supposed to be from 2000 to 2400 feet in length, requiring six to eight lifts of 300 feet each, below water level, to reach the bottom of the basin. We may safely calculate that the company has one square mile, or 640 acres, of available coal on the plane or area of the seams in the deep basin alone, exclusive of a large amount in the middle basin.

At 100 feet thickness, this should yield, by careful mining, 150,000 tons per acre, or nearly 100,000,000 tons to the square mile. There is, therefore, ample room and

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* The foregoing representation of Locustdale gives but a faint idea of the size, character and business aspect of the place. We have failed in our various attempts to get a good picture, and only give this to denote the location of the mines and the general topography of the place. It is a town of about 1000 inhabitants and has a prepossessing appearance.

an abundance of coal for several extensive collieries on this magnificent coal property, the value of which cannot now be properly appreciated.

The accompanying vertical section illustrates the number, thickness and relative position of the coal-beds in the southern or deep basin. There are ten workable seams proved, two of these, I and H, or the Orchards, are *red ash*, and in all probability a portion of B, or the Buck mountain, is also red-ash; while the seams below it are of that color, but the coal partakes of the white-ash variety in character and appearance. The primrose, or G, is known in this region as the "Mahanoy Vein;" it is generally a fine white-ash bed, and is here in its best condition. The Holmes, or F, is here known as the "seven foot;" a tunnel has been driven to it from the Mammoth, and is continued to the Mahanoy, G. The Mammoth itself, as shown by the section on the next page, is a splendid bed, twenty-five to thirty-five feet in thickness, almost pure coal; and is, perhaps, more productive than this at many points, where it is found in excessive enlargements. The dip of this seam, its purity from slate, and the solid character of the "roof" or top slate, render it available to the most economical mode of mining that can be practiced—that known as "runs." In this mode, enough of the broken, or loose coal, remains in the "breast" to keep it full and the miners up to their work; but as the excavated coal requires more than its original space, when in the solid, about one-half of the coal "cut" by the miners is drawn from the "breast," as the work progresses upwards. Thus, when the miners have finished their work in a breast, it will still remain full of coal, and six months or a year may be required to draw it; since each breast contains 10,000 cubic yards of space, and produces about 10,000 tons of coal altogether. The advantages of this mode of mining are, economy in production, and regularity in work. The mine always contains ready coal enough to keep everything in active operation, though the miners may remain idle for months; it was estimated, at one time, that from 80,000 to 100,000 tons of coal were mined in the breast; there are, however, but few localities where this mode can be successfully made use of.

The Skidmore, D, Gamma, C, and Buck mountain, B, are all good workable seams; the latter being sixteen feet in thickness, and is a magnificent bed of coal, almost equal to the Mammoth.

The Locustdale colliery may be considered a model establishment; since it was the first in which the Fan Ventilation was adopted, and the first to adopt machinery and improvements to render a single slope capable of producing 1,000 tons of coal per ton. Such an enormous capacity would have been thought impossible a few years ago, and even now, we find many who doubt the possibility of its accomplishment.

VERTICAL SECTION AT LOCUSTDALE.

But there are now several other slopes in course of development which will be above this capacity. For instance, we may name the New Boston slope. Much mechanical ingenuity and engineering skill are displayed at this colliery, not only in the general plan and development of the mines, but particularly in the automatic regularity with which the heavy mine cars are drawn up a distance of six hundred feet and shot off to the "dump," at the rate of one every two minutes, without manual exertion. One thousand tons of coal can thus be raised readily in ten hours.

Figure 204.

There are two coal breakers at this colliery, which are fully capable of preparing the productions of the mines. The general present capacity of the colliery may be safely put down at 750 tons per day, which may, however, be increased to 1,000 tons, with adequate transportation from the mines to the markets. During 1865 only 82,709 tons were produced, but the mines were nearly half the time idle and never worked beyond half their capacity, on account of the frequent suspensions and the want of cars on the leading lines.

The steam capacity for pumping water, hoisting and preparing coal, and other purposes, is about 600 horse power, and fully equal to the wants of the mines. The ventilation is produced by an exhausting fan, first erected at this colliery, by J. Louden Beadle, the company's general superintendent, in 1857, on the strength of experiments previously instituted, and which has been in successful operation ever since. This is believed to be the first practical application of the suction fan to mine ventilation, and the inventor—Mr. Beadle—has been granted a patent on its use. This mode of ventilation is perfect. It will keep the deepest, most extensive and gaseous mines, free from fire-gas and noxious vapors, and in perfect safety, as far as danger from gases are concerned, provided the air courses are properly constructed, which is essential in all mining operations. The system of fan ventilation now in use has been copied from Locustdale.

SECTION OF MAMMOTH AT LOCUSTDALE.

In view of the many advantages possessed by the Locustdale Coal Company, in the extent and character of their coal lands; the number and size of their coal-beds; the great aggregate thickness of available coal; the favorable position of both seams and basins for mining operations, and the improvement, capacity and perfection of their mining machinery, their lands and mines may be classed among the very best in the Anthracite regions, and second to none in value, availability and economy. Of the characters of the coal, we need only say there is no better.

The officers and directors of the Locustdale Coal Company are:

President,
GEORGE H. POTTS.

Treasurer,
FRANCIS JAQUES.

Secretary,
THEODORE D. EMORY.

Directors,

George H. Potts,
J. Wiley Edmunds,
George B. Upton,
Addison Child,
S. Endicott Peabody.

LACKAWANNA REGION.

No. 4.

ELK HILL COAL COMPANY.

Elk Hill colliery, at Dickson, in Blakely township, on lands owned by Central Coal Company, on Primrose, above water level: Steam-power, 30 horse breaker; average capacity, 70,000 tons per annum; production in 1865, 36,480 tons.

SCRANTON DISTRICT.

No. 5.

HUNT, DAVIS & CO.

(Now Roaring Brook Coal Company.)

Roaring Brook mines, near Scranton, above water level, on Buck Mountain, Gamma and Skidmore, (H, I, K, Scranton nomenclature:) Steam-power, 20 horse; capacity, about 25,000 tons per annum; production in 1865, 11,814 tons.

No. 6.

DELAWARE, LACKAWANNA AND WESTERN RAILROAD CO.

Ten collieries near Scranton, (not including two near Plymouth,) on Mammoth, Primrose and Diamond, (G, E and D, Scranton nomenclature,) below water level: Steam-power, 600 horse; capacity, about 800,000 tons per annum; production in 1864, 652,000 tons, including Boston and Jersey mines at Plymouth; in 1865, 579,615 tons.

No. 7.

LACKAWANNA IRON AND COAL COMPANY.

Pine Brook and other mines, above water level, near Scranton, on Buck Mountain and Gamma, (K, I:) Capacity, 200,000 tons per annum; use all the lump and large sizes of coal at their furnaces and rolling mills.

No. 8.

SUSQUEHANNA AND WYOMING VALLEY RAILROAD AND COAL COMPANY.

Two collieries below Scranton, above water level, coal seams not identified: Steam-power, 115 horse; capacity, 100,000 tons per annum; production in 1865, 56,443 tons.

No. 9.

MYRA J. CLARK.

"Judson Clark's mines," near Providence, below water level, on Mammoth and Skidmore, (H and G:) Capacity, 50,000 tons per annum.

No. 10.

S. T. SCRANTON & CO.

Oxford Mines, Hyde Park, below water level, on Primrose, (E, Scranton nomenclature:) Capacity, 100,000 tons per annum.

No. 11.

MOUNT PLEASANT COAL CO.

"Howell's mines," Hyde Park, below water level, on Primrose, or Scranton, E vein: Steam-power, 85 horse; capacity, 100,000 tons per annum.

No. 12.

A. S. WASHBURN.

Above water level, for home consumption.

No. 13.

PHINNEY & SCHOTT.

Greenwood mines, below Scranton, above water level: Capacity, 80,000 tons per annum.

WYOMING REGION.

No. 14.

PITTSTON DISTRICT.

PENNSYLVANIA COAL CO.

Thirteen collieries near Pittston, below water level, on Mammoth vein: Steam-power, 870 horse; production in 1864, 759,544; in 1865, 577,482 tons.

No. 15½.

GROVE BROTHERS.

Above Pittston, drift on lower veins: Production in 1865, 15,723 tons.

No. 15.

HANCOCK & FOLEY,

(Now Spearing, Foley & Curtis.)

Rough and Ready colliery, above Pittston, on Mammoth vein, below water level: Steam-power, 60 horse; capacity, 30,000 tons per annum; production in 1865, 12,585 tons.

No. 16.

MERCUR & CO.

Thompkin's Shaft colliery, below Pittston, on Mammoth, below water level: Steam-power, 95 horse; capacity, 50,000 tons per annum.

Twin shaft colliery, above Pittston, on Mammoth, below water level: Steam-power, 35 horse; capacity, 40,000 tons per annum; production in 1865, 70,326 tons.

No. 17.

JAMES FREELAND.

In Pittston, above water level.

No. 18.

DAVID MORGAN.

Three collieries: Morgan colliery, three quarters of a mile from Kingston Depot, below water level. Steam-power, 105 horse; capacity, 50,000 tons per annum.

Columbia colliery, in Pittston town ship, three quarters of a mile from the L. & B. R. R. Depot, above water level: Steam-power, 40 horse; capacity, 40,000 tons per annum.

Beaver colliery, in Pittston, above and below water level: Steam-power, 40 horse; capacity, 30,000 tons per annum; production in 1865, 27,499 tons.

No. 19.

MERCUR & FRISBIE.

Three collieries: Eagle Shaft colliery, Seneca colliery, Ravine colliery, in Pittston, below water level, on Mammoth: Steam-power, 181 horse; capacity, 100,000 tons per annum; production in 1865, 26,300 tons.

No. 20.

BUTLER COAL COMPANY.

Butler colliery, in Pittston township, on lands of Butler Coal Company, below water level, on Mammoth vein: Steam-power, 70 horse; capacity, 50,000 tons per annum; production in 1865, 22,040 tons.

No. 21.

MARYLAND ANTHRACITE COAL COMPANY.

Old Benedict and Alton mines, near Pittston, above and below water level, on Mammoth: Steam-power, 15 horse; capacity, 30,000 tons.

No. 22.

ABRAM PRICE.

Price's colliery, Pittston, Pa., on land of A. Price, above water level, on Mammoth vein: Capacity, 20,000 tons per annum; production in 1865, 11,437 tons.

No. 23.

EVERHART COAL COMPANY.

Everhart colliery, near Pittston, on land of Everhart Coal Company, above water level, on Buck Mountain vein: New concern in course of development;

WYOMING REGION.

Figure 207.

No. 37—See Map.

THE UNION COAL COMPANY.

This company own 2,000 acres of land, 1,000 of which is richly underlaid with coal, and 1,000 is covered with valuable timber. They operate three extensive collieries: the "Keystone," at or near Locustdale, in the Mahanoy Region; the "Chauncey," near Plymouth, and a new colliery, in course of development, near Wilkesbarre, in the Wyoming Region. The "Tunnel colliery" was formerly owned and worked by the same company, but it has recently been disposed of to the Schuylkill Mutual Coal Company.

THE KEYSTONE COLLIERY

is on the north dip of the Locustdale basin, and on the same coal-beds which are worked by the Locustdale Coal Company on their south dips. The character and extent of this basin will be found fully discussed in the body of this book, in the general description of the Mahanoy Region—the application is as pertinent to the Keystone as to the Locustdale colliery.

The present operations at this colliery are above water level, by two drifts on the Mammoth, or a water level gangway and a counter level on the upper range of breasts. The height of "breasting," which ranges from 150 to 200 yards, is too great to be worked by a single range of breasts, therefore they are divided into the upper and lower levels. The "run" is one mile west, above the natural drainage, and one mile west and 900 yards east, below, on the Mammoth; but on the underlying seams, the Skidmore, Buck Mountain, &c., the "run" is 2,660 yards east and west.

It is claimed that coal enough remains above water level, in this colliery, to last for ten years, with an average production of 500 tons per day, while the quantity below water level, to the centre of the basin, is immense. The calculation

of the production may be approximately made, by adopting the angles and measurements given in figure 58, page 210, while the number and relative position and thickness of the coal-beds are given in figure 59, page 212.

The present capacity of the Keystone colliery is about 500 tons per day. It is estimated, however, that 1,000 tons per day can be produced from this single colliery, by operating both above and below water level, and we have no doubt of the fact. The steam capacity is 170 horse-power. The character of the coal is well established, and enjoys a high reputation. J. Louden Beadle's exhaust fan is used and the ventilation of the mines is perfect.

No. 40.

THE CHAUNCEY COLLIERY.

This colliery is located near Plymouth, in the Wyoming Region. It is on the Grand Tunnel, or Buck Mountain bed, which is here a fine seam of twenty-five feet thickness. The mines consist of both slope and shaft; the steam-power is 100 horse, and the capacity of the colliery about 50,000 tons per annum.

NEW COLLIERY AT THE WILCOX OPENING.

This colliery is located on Mill Creek, a short distance east of Wilkesbarre, on a large coal estate recently purchased by the Union Coal Company. From a late examination, we conclude all the seams from G to A to exist on this property. A slope has been sunk on a fourteen feet bed, which is supposed to be identical with the celebrated Baltimore bed, or the Mammoth, while an overlying seam of nine feet, only separated by twenty feet of slate, appears to be a "split" of the same.

The slope is 350 yards in length, on an angle of eight degrees. This distance is divided into four lifts of about 250 feet each, with eight gangways, on the Baltimore bed, and an equal number, if so desired, on the upper seam, connected by tunnels with the slope. These four lifts, in the same slope, are operated at the same time by a new and peculiar arrangement. A *train of six mine cars*, of about two tons each, are drawn up at once, so that twelve tons of coal will be hoisted in the same length of time required to lift a single car the same distance by the old and generally used plan.

This colliery is designed and erected with the intention and for the purpose of mining and shipping 1,000 tons of coal per day, which can easily be done from this one slope; but should a larger production be required, there is ample room on the property for several collieries of equal proportion, while a shaft will be required to develope the deeper coal of the underlying seams at this colliery. The steam-power is 250 horse, and the breaker capacity calculated to meet the productions of the mine.

Of the character of this coal we need not speak, since the Baltimore coal-bed, in the vicinity of Wilksbarre, has long been celebrated for the production of the most excellent coal, which is equal to any that goes to market, without exception.

The officers and directors of the Union Coal Company are:

President,
E. A. QUINTARD.

Secretary,
WM. MACFARLANE.

Treasurer,
S. L. CROSBY

Directors,

E. A. QUINTARD, H. T. LIVINGSTON, EDWARD L. BAKER
FRANCIS SKIDDY, JOSEPH R. SKIDMORE, N. L. McCREADY,
GEORGE W. ELDER.
H. H. FISHER, *General Agent.*

No. 24.

T. & W. LEYSHON.

Bowkley & Leyshon's mines, near Pittston, above and below water level, on Primrose and Mammoth: Steam-power 20 horse.

WILKESBARRE DISTRICT.

No. 25.

WYOMING COAL AND TRANSPORTATION COMPANY.

Burrough's colliery, three miles north of Wilkesbarre, below water level, on Mammoth vein: Steam-power, 70 horse; capacity, 75,000 tons per annum; production in 1865, 36,051 tons.

No. 26.

H. B. HILLMAN.

Hillman's mines, on Hollenback's land, above Wilkesbarre, above water level, on Primrose vein: Production in 1865, 7,408 tons.

No. 27.

BALTIMORE COAL COMPANY.

Three collieries, on Mammoth vein, above and below water level, near Wilkesbarre: Steam-power, 400 horse; capacity, 1,000 tons per day; production in 1864, 133,953 tons; in 1865, 128,575 tons.

No. 28.

CONSOLIDATED COAL COMPANY.

(Now Wilksbarre Coal and Iron Co.)

Seven collieries, near Wilkesbarre, on Buck Mountain, Mammoth and Orchard veins, above and below water level: Steam-power, 815 horse; capacity, 500,000 tons per annum; production in 1864, 226,012 tons; in 1865, 225,154 tons, (Lee's colliery, at Nanticoke, is leased by this company, and is the only one on the Buck Mountain bed.)

No. 29.

AUDENRIED COAL & IMPROVEMENT COMPANY.

Audenried colliery, near Wilkesbarre, below water level, on Mammoth, &c.: Steam-power, 200 horse; capacity, 50,000 tons per annum; production in 1864, 15,703 tons; in 1865, 33,405 tons.

No. 30.

FRANKLIN COAL COMPANY.

Old Wilkesbarre Coal Company, near Wilkesbarre, below water level, on Mammoth vein: Steam-power, 200 horse; capacity, 50,000; production in 1864, 29,333 tons; in 1865, 41,942 tons.

No. 31.

LANDMESSER & CO.

Colliery near Wilkesbarre, below water level, on Mammoth vein: Production, 18,489 tons.

No. 32.

LEHIGH AND SUSQUEHANNA COAL COMPANY.

Colliery near Wilkesbarre, below water level, on Mammoth and Primrose veins: Steam-power, 136 horse; capacity, 400 tons per day; production in 1864, 20,896 tons; in 1865, 31,859 tons.

No. 34.

NEWPORT COAL COMPANY.

New concern: Not developed; in lower end of Wyoming or Newport Valley, on Mammoth and lower veins.

No. 40.

UNION COAL COMPANY.

New mines on Mill Creek, south-east of Wilkesbarre: Slope on Mammoth, not yet complete. (For further information in regard to these mines, see No. 37, Mahanoy Region, and a special description, on another page.)

WYOMING REGION.

No. 35.

PLYMOUTH DISTRICT.

KINGSTON COAL COMPANY,

Near Kingston, below water level, (mines full of water at time of visit:) Steam-power, 115 horse.

No. 6—See Map.

DELAWARE, LACKAWANNA AND WESTERN RAILROAD CO.

Boston mines, near Plymouth, above water level, on Mammoth vein: Steam-power, 30 horse; capacity, 100,000 tons per annum.

Jersey mines, above water level, on Buck Mountain vein: Capacity, 50,000 tons per annum.

No. 37.

SHAWNEE COAL COMPANY.

Shawnee mines, near Plymouth, above water level, on Mammoth vein: Capacity, 100,000 tons per annum; production in 1865, 27,296 tons.

Nos. 36 and 38.

J. LANGDON & CO.

(Now H. S. Mercur & Co.)

Sweatland Colliery and Gaylord mines, both below water level, on Mammoth and Primrose veins: Steam-power, 186 horse; capacity, 100,000 tons per annum; production in 1865, 39,911 tons.

No. 39.

WASHINGTON COAL COMPANY,

Near Nanticoke, above water level, on Buck Mountain vein: Steam-power, 25 horse; production in 1865, 15,456 tons.

No. 40.

UNION COAL COMPANY.

Old Chauncey mines, near Plymouth: Shaft and slope, on Grand Tunnel or Buck Mountain vein; steam-power, 40 horse breaker engine; production in 1865, 18,012 tons.

(See No. 40, Wilkesbarre District, and No. 37, Mahanoy Region.)

No. 41.

WATERMAN & BEAVER.

(David Morgan.)

Montour colliery, near Nanticoke, above and below water level, on Mammoth vein: Steam-power, 100 horse; capacity, 25,000 tons per annum; production in 1865, 8,863 tons.

No. 42.

WEST BRANCH COAL COMPANY.

Colliery near Nanticoke, above water level, on Mammoth vein: Steam-power, 40 horse.

No. 43.

GRAND TUNNEL COAL CO.,

Near Nanticoke, above water level, on Buck Mountain vein.

No. 44.

HARVIE BROTHERS.

Near Nanticoke, above water level, on Buck Mountain vein: Steam-power, 12 horse; capacity, 30,000 tons per annum: production in 1865, 11,852.

No. 45.

CAREY AND HART.

Near Shickshenny, above water level, on Buck Mountain vein.

(New operation, not fully developed.)

No. 46.

SALEM COAL COMPANY.

Rocky Mountain colliery, near Shickshenny, above water level, on Buck Mountain vein.

NEW ENGLAND COAL COMPANY.

WYOMING AND LACKAWANNA REGIONS.

We must here call attention to the estimated capacity of the collieries, not only in this but in other regions, as entirely arbitrary. Some have returned a fair estimate, while others are much too high. This will explain why the capacity of several comparatively small operations are returned as greater than that of much larger establishments. The general capacity, however, as given, could be nearly approximated, if the demand and the means of transportation were equal to the mining capacity.

We have no other means of obtaining the respective shipments of the operators in the Northern Anthracite field than by the Revenue Commissioners' returns; but while these give the total correctly, the respective production of the mines vary widely, since the large shippers buy from the smaller producers. For instance, the shipments of the Delaware, Lackawanna and Western Railroad Company are taxed as 937,631, while their mine production was only 579,615 tons in 1865, leaving 358,016 tons purchased from other mines. The same policy has been pursued by other large companies, consequently the Commissioners' returns do not give the full production of the smaller coal producers. We give, however, a list of the shippers, as found on the Assessor's books, with the exception of those formerly given and located on the map.

LACKAWANNA AND WYOMING REGIONS.

	Tons.
CARBONDALE.	
James Nickol	2,670
John Oakly	603
S. S. Clark	2,568
Elias Palmer	150
J. P. Williams and Sons	806
O. W. Spangenberg	97
ARCHIBALD.	
Wm. Shea & Co.	129
W. D. & D. R. Moore	2,419
SCRANTON.	
Rapp & Bowen	5,760
F. J. & J. Williams	1,760
Christian Scherer	1,459
PROVIDENCE.	
Joseph Church	1,214
Lackawanna Coal Company	89
Charles Edwards	258
Flynn & Morris	263
Griffin & Ritner	50
Hughes & Abel	243
F. B. Marsh	624
Giles Leach	466
Wm. Henry	105
Michael Rock	537
Williams & McFarlane	229
L. Van Storch	270
J. T. Heatherby & Co.	65

BLAKELY.	
Martin Crippin	151
HYDE PARK.	
Lackawanna and Susquehanna Coal and Iron Company	5,693
PITTSTON.	
Shiffer & Lacoe	849
De Witt & Salisbury	5,563
KINGSTON.	
C. S. Maltby	4,817
J. D. & H. M. Hoyt	469
James P. Atherton	242
WILKESBARRE.	
Parish & Thomas	8,210
Warrior Run Coal Company	780
Rodman Merritt	350
J. R. Stark	200
PLYMOUTH.	
Ira Davenport	858
New England Coal Company	12,507
H. S. Mercur & Co. (successor to Langdon)	17,302
R. N. Smith	1,500
James Nicholas	500
SHEIKSHENNY.	
A. A. Church	106

FIRST, OR SOUTHERN COAL FIELD.

LEHIGH DISTRICT.

Figure 946.

MT. PISGAH PLANES AND GRAVITY RAILROAD.

No. 17.

LEHIGH COAL AND NAVIGATION COMPANY.

The coal lands of this Company extend from a point near Tamaqua to the eastern extremity of the First, or Southern Anthracite Coal Field, and contains 6,000 acres. Their mines are the "East Lehigh," "Room Run," "Summit Hill," "Panther Creek," and "Tamaqua." We include, however, under Number 17, as marked on the map, only the "East Lehigh," "Summit Hill," and "Panther Creek" Mines. There are seven collieries in operation at these mines, on the Buck Mountain and Mammoth veins, with 2,485 horse-steam-power, and a capacity of about 500,000 tons per annum. The production of 1863, was 410,689 tons; 1864, 373,104 tons; 1865, 408,171 tons. The total production of Lehigh Coal and Navigation lands is:

	Tons. C.
From Summit Mines, by Lehigh Coal and Navigation Co......	408,171.18
From Summit Dirt Heaps, leased............................	3,542.12
From Room Run Mines, "	79,753.08
From Tamaqua " "	19,535.07
From Greenwood " "	6,022.02
Total for 1865...............................	517,025.07

No. 18.

DOUGLASS, SKEER & CO.

Room Run mines, at Nesquehoning, on Buck Mountain and Mammoth veins: Two collieries below water level; steam-power, 800 horse; capacity, 100,000 tons per annum; production in 1864, 86,700 tons; in 1865, 79,753 tons.

No. 19.

MOSS, WOOD & CO.

Tamaqua Lehigh mines, near Tamaqua, on Mammoth vein, below water level: Steam-power, 135 horse; capacity, 50,000 tons per annum; production in 1864, 34,865 tons; in 1865, 19,535 tons.

TAMAQUA DISTRICT.

No. 1.

GREENWOOD COAL COMPANY.

Greenwood mines, west of Tamaqua, above and below water level, on Mammoth, (all, or most of the Anthracite seams to I, or Diamond, existing on the property:) Steam-power, 190 horse; capacity, 100,000 tons per annum; production in 1864, 56,375 tons; in 1865, 71,369 tons.

No. 2.

JOHNSON & ORMROD.

At D, east colliery north of Tamaqua, on lower veins, above water level: Steam-power, 30 horse; capacity, 20,000 tons per annum; production in 1864, 19,456 tons; in 1865, 13,618 tons.

No. 3.

GEORGE BROWN.

(Now Whetmore & Moss.)

At High mines, north of Tamaqua, on Primrose, (Tamaqua F,) below water level: Steam-power, 100 horse; capacity, 30,000 tons per annum; production in 1865, 13,872 tons.

No. 4.

RATCLIFFE & RALSTON.

At C, West mines, Tamaqua, below water level, on Buck Mountain: Production in 1865, 5,640 tons.

No. 5.

LITTLE SCHUYLKILL COAL AND NAVIGATION COMPANY.

Five collieries, including Shaft colliery at Tamaqua, and Buckville colliery, west of Tamaqua, below water level, on Mammoth, or E: Steam-power, 760 horse; capacity, 100,000 tons per annum; production in 1865, 48,389 tons.

No. 6.

GEORGE W. COLE.

Reevesdale mines, west of Tamaqua, on Mammoth, above water level: Steam-power, 20 horse; capacity, 50,000 tons per annum; production in 1865, 13,170 tons.

POTTSVILLE DISTRICT.

No. 8.

MAMMOTH VEIN CONSOLIDATED COAL COMPANY.

Three collieries: Tuscarora colliery and Smith colliery, near Tuscarora; tunnel at Tuscarora colliery, commenced in Palmer (H) and driven through Mammoth to Skidmore, above water level; steam-power, 30 horse; slope at Smith colliery on Mammoth; steam-power, 170 horse.

Hickory colliery, at St. Clair, and New Hickory Shaft colliery, at Wadesville.

(See description, further on page 765.)

No. 9.

HENRY GUITERMAN.

Coal Hill colliery, above New Philadelphia, on Valley Furnace Tract: Slope 210 yards long, on Skidmore; steam-power, 50 horse power; capacity 50,000 tons per annum; production in 1865, 16,074 tons.

No. 11.

FOSTER & SILLIMAN.

No. 12.

HINE, LORE & CO.

Gate Vein colliery, on Valley Furnace Tract, above New Philadelphia: Production in 1865, 3991 tons.

No. 18.

RICHARD WINLACK & CO.

Two collieries: One at Silver Creek, and one on "Busby tract," above New Philadelphia, below water level, on H and M; steam-power, 100 horse; production in 1865, 10,591 tons.

No. 14.

NEW PHILADELPHIA COAL MINING COMPANY.

Two collieries: Novelty colliery, below New Philadelphia. Slope on Gate or M, 1,008 feet deep; steam-power, 80 horse; and a new colliery, known as the Road's Shaft colliery at New Philadelphia, on Gate, 258 feet deep; steam-power, 70 horse; capacity of both collieries, 50,000 tons; production in 1865, 24,565 tons.

No. 15.

KASKA WILLIAM COAL CO.

Above Middleport, on Mammoth and lower veins, (mines on fire;) production in 1865, 4,266 tons.

No. 19.

MILLER & MAIZE.

Warrenton colliery, near New Philadelphia: Two slopes, on Primrose and Holmes; tunnel proposed to Mammoth; steam-power, 240 horse; capacity, 75,000 tons per annum; production in 1865, 12,116 tons.

No. 20.

CHARTER OAK COAL COMPANY.

(Formerly Bedall & Robinson.)

Near Belmont, on Primrose, Orchard and Diamond, above and below water level: Steam-power, 100 horse; production in 1865, 37,640 tons.

No. 21.

BELMONT COAL MINING CO.

Belmont mines: Shaft on Tunnel vein, (Gate,) 75 yards deep; steam-power, 50 horse; production in 1865, 8,913 tons.

No. 22.

EAGLE HILL SHAFT COAL CO.

Eagle Hill colliery, above Belmont: Two shafts on Mammoth and Seven Foot Veins; steam-power, 110 horse; productions in 1865, 39,375 tons.

No. 23.

M. G. HEILNER.

(Now Mutual Consumers' Coal Co.)

Oakland colliery, above Belmont, below water level on Mammoth and Skidmore: Steam-power, 165 horse; production in 1865, 4,877 tons.

No. 24.

WILLIAM DOVEY.

Near Belmont, new place on Red Ash Veins: production in 1865, 5,128 tons.

No. 25.

FEEDER DAM COAL COMPANY.

Between Belmont and St. Clair, place formerly worked by Messrs. Potts & Snyder, on Red Ash Veins; production in 1865, 6,113 tons.

No. 26.

A. LAWTON—POTTSVILLE GAP COLLIERY.

On the Sharp Mountain, near Pottsville, Buck Mountain (Barclough) vein: Red-ash coal, above and below water level; steam-power, 35 horse.

No. 29.

WILLIAM H. STARR.

Peach Mountain colliery, between St. Clair and Port Carbon, at Ravensdale: Slope on Primrose, 190 yards deep; other seams below Primrose, accessible by tunnel or shaft; steam-power, 65 horse; capacity, 50,000 tons per annum.

No. 18.

STAR COAL COMPANY.

Fig. 200.

This Company owns the leases of two very fine collieries; one on the Mammoth and lower veins, known as the "Silver Creek Colliery," at Silver Creek, near New Philadelphia; and the other, above Minersville, on the Mine Hill and Schuylkill Haven Railroad, known as the "Diamond Colliery," on the Diamond Orchards, and other red-ash seams.

SILVER CREEK COLLIERY.

This colliery is on the Mammoth vein, 30 feet thick. The slope is 107 yards deep, from the bottom of which the Skidmore and "seven foot" are reached by tunnel. The machinery consists of one 60 horse pumping-engine, one 40 horse hoisting-engine, and a 20 horse-power breaker engine. This colliery, under full development, is capable of producing from 75,000 to 100,000 tons per annum.

DIAMOND COLLIERY.

This colliery is opened by two slopes on the Diamond vein, with tunnels proposed to the "Morgan Brace" (Tracy) Orchards, and other seams. The machinery consists of one 50 horse pumping, one 25 horse hoisting and breaking, and one 10 horse-power breaking-engine. This colliery, under fair development, will produce 50,000 tons per annum, and may be made to produce much more.

THE STAR COAL COMPANY.

This Company was organized under the laws of the State of Pennsylvania, January, 1865, with a capital of $350,000, and has since been successfully working and increasing its capacity for production. The property of the Company is located in Schuylkill county, and consists of valuable leases of the celebrated *Guiterman Silver Creek Colliery*, near New Philadelphia, and the *Diamond Colliery*, near Minersville. The Silver Creek embraces all the *white-ash* coal veins in the Schuylkill region, known as the Skidmore, 12 feet thick, the Mammoth, from 25 to 35 feet thick, and other smaller veins. The Diamond comprises three veins of *red-ash* coal, viz., the Diamond, South Diamond, (Tracy,) and the Cockle veins, (Orchard,) all of the purest quality. The Company's improvements consist of two slopes and breakers now in operation, and one slope and breaker not at present working. The machinery employed, and as above described, is well adapted to a large and successful business.

This organization presents some peculiar features. It combines the *mutual* with the *joint stock* principle, giving to all its stockholders the privilege of receiving coal at wholesale prices, and making regular quarterly dividends in cash. The Company possesses the advantages of convenience in the locality of its collieries for ready and easy shipments; small cost of lateral tolls, and facilities for shipping, either by railroad or canal, to Philadelphia and New York, which are very important advantages.

This Company presents some excellent features in its organization and management, holding desirable leases on some of thq best and most valuable veins of coal in the county, with its entire capital paid in, and a surplus of $30,000 in stock, and $10,000 in the treasury. The stock has been principally taken as a permanent investment, and promises to prove an increasingly profitable one, if well managed, especially when the very large coal deposits of the Company, altogether more than three miles in extent, as yet unopened, shall havebeen developed. The Company contemplates adding another breaker, and enlarging its operations.

Wm. H. Starr, Esq., of New London, Conn., who has several years of practical experience in coal mining in this county, is *President* of the Company.

Wm. H. Chapman, Esq., President of the National Union Bank of New London, is *Secretary and Treasurer*, and its *Directors* comprise some of the leading business men of that place.

The office address of the Company is New London, Conn.

No. 30.

POTTSVILLE MINING AND MANUFACTURING COMPANY.

Three collieries: Orchard colliery, Lewis colliery and Ball's colliery, between St. Clair and Pottsville, on Gate and other red-ash veins; steam-power, 200 horse; capacity, 50,000 tons per annum; production in 1865, 31,811 tons.

No. 31.

GROSS, CLARKE & CO.

(Kirk & Baum's old place.)

Near St. Clair, on Primrose and Holmes, below and above water level: Steam-power, 250 horse; production in 1865, 28,827 tons.

No. 33.

ST. CLAIR COAL COMPANY.

Shaft colliery and Slope colliery, at St. Clair, on Mammoth: Steam-power, 750 horse; capacity, 100,000 tons per annum; production in 1864, 67,476 tons; in 1865, 37,844 tons. (Shaft colliery Breaker destroyed by fire during 1865.)

No. 35.

P. BRENE.

Mill Creek Gap, above St. Clair: Drifts on Skidmore and Buck Mountain; steam-power, 20 horse.

No. 36.

PRIMROSE AND PEACH MOUNTAIN COAL COMPANY.

In St. Clair: New concern, now under development; steam-power, 120 horse; capacity, 50,000 tons per annum.

No. 37.

GEORGE S. REPPLIER.

Mammoth colliery, junction of Wolf Creek and Mill Creek, above St. Clair: Two slopes on Mammoth, one 758 feet deep; steam-power, 440 horse; capacity, 75,000 tons per annum; production in 1865, 38,762 tons.

No. 38.

MANCHESTER COAL COMPANY.

Wadesville, (C. Frantz's old place:) Slope on Primrose and Orchard; steam-power, 80 horse; production in 1865, 32,920 tons.

No. 39.

CHARLES SAYLOR, Agent.

Above Wadesville: Slope on Primrose; steam-power, 50 horse; production in 1865, 14,083 tons.

No. 40.

JOB RICH.

Near Pottsville: Small operation for home consumption.

No. 41.

DUNCAN COAL COMPANY.

On Mount Carbon Railroad, Peach Mountain or Gate vein, below water level: Production in 1865, 23,858 tons.

No. 42.

NORWEGIAN COAL COMPANY.

Brown's old Oak Hill and Price Wetherill collieries, at Oak Hill, on the Mount Carbon Railroad: One shaft and three slopes on Primrose, sinking to Mammoth; steam-power, 340 horse; capacity, under full development, 100,000 tons per annum; production in 1864, 19,664 tons; in 1865, 7,407 tons.

No. 43.

MOUNT CARBON COAL CO.

Wm. Williams' old colliery, at Mount Laffee: Shaft on Primrose, sinking to Mammoth; steam-power, 65 horse; capacity, 70,000 tons per annum; production in 1865, 7,068 tons.

No. 44.

EAST MOUNT LAFFEE COAL CO.

Mount Laffee colliery, at Mount Laffee: Slope on Mammoth; steam-power, about 150 horse; sinking and preparing for operation.

SCHUYLKILL HAVEN DISTRICT.

No. 45.

NEW HAVEN COAL COMPANY.

West Mount Laffee colliery, at Mine Hill Gap: Slope on Mammoth; steam-power about 125 horse; idle during 1865.

No. 46 and 48.

WILLIAM H. STARR.

Diamond colliery. (See Star Coal Company, No. 18.)

No. 47.

R. C. HILL.

Patten's Old Mine colliery, at Mine Hill Gap, on Mammoth, below water level.

No. 49.

WILLIAM KEAR & CO.

Mine Hill Gap colliery, near Coal Castle: Slope on Mammoth; steam-power, 350 horse.

Wolf Creek Diamond colliery, near Minesville, on Primrose and Diamond: Steam-power, 150 horse; production in 1865, 76,571 tons.

No. 51.

WILLIAM LITTLEHALES.

(Now New Castle Mutual Coal Co.)

Patterson colliery: At Greenberry, Mine Hill Basin, on Buck Mountain, (Jugular,) above water level; production in 1864, 4,400 tons.

No. 52.

NEW YORK AND SCHUYLKILL COAL COMPANY.

Heckscherville colliery, on (Jugular) Daniel, Mammoth and other lower veins: Two slopes and two tunnels; steam-power, 730 horse; capacity, 150,000 tons per annum; production, 90,000 tons.

Thomaston colliery, north side of Mine Hill, Mammoth, Skidmore and Buck Mountain: Shafts 83 yards deep; steam-power, 210 horse; capacity, 180,000 tons per annum; production, 120,000 tons.

Otto Red-ash colliery, south side Mine Hill, on Black Heath and split of Mammoth, (same as at Wolf Creek:) One slope, 320 yards long; steam-power, 270 horse; capacity, 150,000 tons per annum; production, 80,000 tons.

Black Heath Colliery, south side of Mine Hill, on Black Heath, Skidmore, and and Back vein (above water-level); steam-power, 60 horse.

North Tunnel Colliery, south side of Mine Hill, on Mammoth, above water-level; capacity, 40,000 tons; production, 20,000 tons.

Forestville Colliery, at Forestville, on Mammoth and lower veins. Slope 300 yards long; steam-power, 140 horse; capacity, 100,000 tons; production, 70,000 tons.

Total shipments from the six collieries in 1865, 172,558 tons.

No. 52½.

T. H. SCHOLLENBERGER, Agent.

Near Glen Carbon, on Mammoth and other White Ash Veins: Production in 1865, 44,190 tons.

No. 53.

GLEN CARBON COAL COMPANY.

Glen Carbon colliery, above Heckscherville, in Mine Hill Basin: Slope on Mammoth and other White Ash veins; steam-power, 135 horse; capacity, 50,000 tons per annum; production in 1865, 25,563 tons.

No. 54.

B. HAMMET.

Peaked Mountain colliery, in Mine Hill Basin, on Mammoth and other veins: Three drifts, three tunnels, two shafts, one slope; steam-power, 520 horse; capacity, 100,000 tons per annum; production in 1865, 21,603 tons. (Burned out in March, 1865; started in July same year.)

No. 55.

PEOPLE'S MUTUAL COAL CO.

Near Monterey, on Mammoth and other veins: Production in 1865, 44,190 tons.

No. 56.

GORMAN & WINTERSTEIN.

Near Monterey, repairing Taylor's old place.

No. 58.

BLACK HEATH COAL COMPANY.

Serrill's old place, near Minesville, above water level, on Mammoth, Skidmore and Buck Mountain, (locally known as Black Valley, Skidmore and Spring veins:) Steam-power, 20 horse; production in 1865, 12,802 tons.

Figure 110.

No. 6.

MAMMOTH VEIN CONSOLIDATED COAL COMPANY.

This great coal company own and operate eight of the largest collieries, including the new shaft at Wadesville, in the Anthracite Regions, and all of them are on the Mammoth Vein, which is the greatest coal bed of the anthracite fields. Among these, the Hickory Colliery, at St. Clair, one of the oldest and most successful in operation, claims our special attention. This colliery is located in the second basin south of the Mine Hill range—John's intervening—which, in this vicinity, has invariably produced the most excellent coal, while the Mammoth is here uniformly found in its best workable condition, and from 20 to 30 feet in thickness. The old Hickory Colliery, formerly Milnes', has been constantly productive for a period of over 20 years, and promises to be equally available for many years to come; while the new Hickory Shaft Colliery, now in course of development, to the dip of the old workings, and to the west of the same, at Wadesville, will command a breasting of 1,200 feet on the Mammoth with a "run" on the "strike" of the same of two miles. The seven foot and the underlying Skidmore and Buck Mountain beds are also available in the shaft colliery with an equal run, and greatly increased breasting.

This new, colliery, being designed and executed with a view to permanence, economy of production, and the most approved mining appliances, promises to be one of our most extensive and productive colliery establishments. The Hickory coal has always enjoyed a high reputation in market, and justly so, because none better is produced in the Anthracite Regions. We consider the Hickory, Pine Forest and John's Eagle Colliery coals, as equal to the best Locust Mountain or Lehigh, both in appearance and availability. The present capacity of the old Hickory is about 120,000 tons per annum; while the new Hickory is estimated to produce from 150,000 to 200,000 tons. The aggregate steam-power at the old works is 350 horse; at the new works 650 is proposed, or a total of over 1000 horse-power. The size of the new shaft is 14 by 22 feet, and the estimated depth to the Mammoth about 600 feet.

The Mammoth Vein Consolidated Coal Company, in addition to the Hickory Collieries, own and operate two collieries near Tuscarora (see No. 8 on map), in the Southern Coal Field, and four collieries in the Mahanoy Region, of the Middle Coal Field; namely, the Mahanoy Valley, Locust Mountain, Locust Gap and A. S. Wolf Collieries, (see No. 11 on map,) all on the Mammoth Vein.

W. H. SHEAFER, ESQ., is the general agent of this company.

Figure 211.

No. 28.—See Map.

PINE FOREST COLLIERY.

GEORGE W. SNYDER.

George W. Snyder's Pine Forest colliery has been in active operation during a period of twenty years, and has always been productive, with a capacity of about 100,000 tons per annum; and, perhaps, no coal sent to market has been, invariably, so well prepared, during "good" as well as "bad times," as the "Pine Forest," or that has constantly enjoyed a better reputation among coal consumers.

The old Pine Forest colliery is near the town of St. Clair, and on the southern slopes of the celebrated Mine Hill range, along which the white-ash coal-beds are generally in their best condition, and extremely productive; but at no point south of the Mine Hill are they so uniformly good as in this vicinity.

The veins worked in the Pine Forest colliery are the "Seven Foot" Mammoth and Skidmore. For a considerable period they were productive above water level, but the third "lift" below is in operation through the Pine Forest slope; while the fourth "lift" is being opened by the new Pine Forest shaft, which is now in course of development, as illustrated in Figure 209.

The old Pine Forest colliery will be productive for a considerable length of time yet, and the combined capacity of both establishments may be stated at 250,000 tons per annum. There are two slopes at this colliery, on the Mammoth, connected by tunnels with both the "Seven Foot" and Skidmore, and the aggregate power of the hoisting and pumping engines thereon is 180 horse. The breaker engine is 40, and the dirt-plane engine 40 horse-power; while a small locomotive engine is used for the purpose of conveying the mine cars from point to point on the surface; the total steam-power at old Pine Forest, being about 250 horse.

PINE FOREST SHAFT COLLIERY.

Figure 212.

The new Pine Forest shaft colliery is now in course of development, by a shaft sunk to the dip of the old Pine Forest works, near the bottom of the second basin south of the Mine Hill,—that known as Johns' basin being the first. This shaft is 12—20 feet in size, and about 330 feet in depth to the Mammoth. It is intended, however, to reach the Skidmore, which is about 450 feet from the surface, and perhaps, eventually, the Buck Mountain vein. The character of the work and improvements at this new colliery are substantial and well designed for permanence and economy of operations. The hoisting machinery consists of a pair of engines connected to the same shaft at right angles with link motion,—cylinders, 20 inches diameter, by four feet stroke, and capable of elevating 1000 tons of coal per day. A large "Bull Engine" is erected for the purpose of drainage, with a 60 inch cylinder, 10 feet stroke, and two columns of 20 inch pipes in two lifts. The breaker is 40, and the dirt-plane engine 30 horse-power; giving a total steam-power, at the shaft, of about 725 horse, or an aggregate at both collieries of 1000 horse-power.

The engines for the new shaft, in particular, are of great strength and simplicity, and admirable as models of mining machinery. Mr. Snyder builds his own machinery at his old and justly celebrated Pottsville Machine works and foundry.

(Mammoth E.)

The extent of "breasting" on the dip of the seams, from the dip workings of the slope to the levels of the shaft, is from 400 to 500 feet; while the "run" on their "strike" is about one and three-quarter miles. The Mammoth is here from 20 to 30 feet in thickness, the Skidmore 8 feet, and the "Seven Foot" 8 feet; while the Buck Mountain vein has been found in the vicinity 10 feet thick. The aggregate thickness of workable coal is, therefore, about fifty feet, and the amount available at these collieries, including the basin, to the dip of the shaft, not less than 10,000,000 tons.

(Skidmore D.)

SECTIONS OF PINE FOREST COAL SEAMS.

The moderate dip of the measures in the new shaft colliery, the number of seams, and the proximity to the basin, offer an admirable opportunity of introducing the best and most improved systems of mining and ventilation; while the extensive and substantial style of the improvements and the power of the machinery combine to render this colliery one of great capacity, and among the best of our new and approved mining establishments. The breaking and coal-preparing arrangements are ona large scale, and erected with a view to the careful preparation of the coal for market, as well as capacity for production We may, therefore, safely state, that the *Pine Forest coal in the future will sustain its reputation in the past.*

Figure 213.

No. 34.

GEORGE W. JOHNS & BRO.

This colliery has always been conducted in the most practical and economical manner, having been developed and improved by two practical and prudent miners, Thomas Johns and the late William H. Johns, who did their work in the most substantial manner, and with the great objects of availability and economy in operation constantly in view. The consequence is, that this has been one of our most successful—if not our most successful—collieries; and has realized for its prudent and fortunate possessors over a million of dollars in net profits.

It is not, and has not been, a better location than many others we might name; nor has the Mammoth here—though uniformly good and productive of splendid coal—been superior in size, or economy of production, to the same magnificent bed in many other places, where it has not been so profitably worked. In mining, as in all other pursuits, practical experience, and a careful, energetic management, is almost always certain of success, and always certain, when the coal exists in comparatively large seams, and is free from fault and impurity.

The Eagle Colliery is capable of producing 100,000 tons per annum. Its production has been about 75,000 tons per annum. During 1864, 84,558; 1865, 74,745 tons were shipped. It is on the Mammoth Vein, above and below water level; its steam machinery consists of an aggregate of 200 horse-power. The colliery is located at the upper end of the town of St. Clair.

No. 50. See Map.

PINE KNOT COAL COMPANY.

CAPITAL $500,000.

Figure 214.

MINE HILL BASIN, AT COALCASTLE.

The East and West Pine Knot Collieries are located on the south dips of the Mine Hill Basin, at the base of the Broad Mountain, and opposite Mine Hill Gap. The East Colliery occupies the site of the old and celebrated Greenberry Mines, which, for a long period, produced large quantities of the most excellent coal above water-level. The West Colliery is on the site of the old Daniel Mines, one of the first worked in the Mine Hill Region, and which was also operated for a long period above water-level. The distance between these two collieries is about one and a half miles, and the entire "run," on the "strike" of the veins, is about *three miles;* or from the Heckscherville Collieries on the west, to a point near Newcastle on the east.

The coal-beds worked are locally known as the Mammoth, or Daniel, Lelar, Crosby, and Big Diamond—the probable equivalent of the Mammoth, Skidmore, Gamma, and Buck Mountain. Behind these, to the north, and available to either slope by tunnel, is a repetition of both the north and south dips of all the lower coal-beds, including the Mammoth, in what may be called the Inverted Jugular Basin, as shown in figure 214.

The Pine Knot Collieries are on the right side of the above figure and on the south dips of the first basin, which includes the six upper seams only. It is plain, however, that all the beds are repeated in the second, or North (Jugular) Basin, except the two upper ones, and that they may be reached and operated from the Pine Knot slopes with much economy. Thus, *twelve* coal-beds may be worked at one time at these collieries, which cannot be said of many other mining establishments.

In November, 1863, these collieries were purchased by H. W. Fuller, Esq., of Boston, and since then a thorough system of improvement has been introduced and carried out, involving the expenditure of large sums of money.

At the West Colliery a large and substantial breaker, on the most approved plans, has been erected, with new engines, engine houses, &c., &c. The slope has been thoroughly repaired, and tunnels driven to the Lelar and Crosby, at the second lift. At the East Colliery the pumping slope has been improved, and a new and powerful Cornish, or "Bull," Engine, with a fifty-three inch cylinder erected, and two new columns of twenty-inch pipes laid down. This engine alone—without the assistance of two other large pumping-engines—is of sufficient capacity to drain the workings of both collieries. The old coal slope at this colliery has been enlarged to 11 by 28 feet, and newly timbered to the bottom of the first lift. It is to be

extended to the second lift immediately, and a new and improved coal-breaker erected thereon.

The aggregate steam-power employed at these collieries is eight engines, and about 750 horse-power, of which 200 horse is used for hoisting coal, 500 for pumping, and 50 for breaking and preparing. The capacity of the mines is about 100,000 tons per annum, and when fully developed should reach 1,000 tons per day.

Repplier's Mammoth Colliery adjoins the Pine Knot on the east; the New York and Schuylkill Coal Company's Collieries, at Heckscherville, on the west, and Wm. Kear & Co.'s Mine Hill Gap Colliery on the south. All these celebrated mines are on the same veins as the Pine Knot, and the character of the coal produced from the entire basin is excellent. It is as dense as the coal of the Lehigh, and as available for all the purposes in which the hard anthracite is used.

The expenditure in developing these collieries is heavy, but, considering the number of coal-beds which are accessible by either slope, and the great length of the "run,"—on which twenty-four gangways may be driven at each lift—we consider that the work accomplished so far has been done with judicious economy, and with a view to permanence and availability in improvements and production.

The officers of the Pine Knot Coal Company are:

President, William S. Eaton, Boston; *Secretary*, Simon Levi, Boston; *Treasurer*, H. W. Fuller, Boston.

Edwin Harris, Minersville, *Agent and Superintendent.*

No. 61.

PHŒNIX PARK COAL COMPANY.

Four collieries: One and-a-half miles north-west of Minersville, on 1,000 acres of land owned by this company. At present working Primrose, Orchard and Diamond: Steam-power, 350 horse; production in 1865, 39,854 tons.

No. 62.

GOODMAN DOLBIN.

Lytle colliery, Woodside, below water level, on Diamond: Steam-power, 50 horse; capacity, 35,000 tons per annum; production in 1865, 17,673 tons.

No. 64.

HOUSEKEEPERS' COAL CO.

At Branchdale, below water level, on Spohn or Gate vein: Steam-power, 70 horse.

Nos. 65 and 66.

SWATARA FALLS COAL CO.

Two collieries at Swatara Falls, on Mammoth and other seams, above and below water level: Production in 1865. 62,630 tons.

No. 67.

GILFILLAN & LYNCH.

Swatara colliery, near Swatara Falls. above water level, on Mammoth veins, (split:) Steam-power, 15 horse; production in 1865, 12,617 tons.

No. 68.

TREMONT COAL COMPANY.

(Formerly C. Garretson.)

Middle Creek, west of Swatara, on Mammoth, above and below water level: Steam-power, 120 horse; capacity, 50,000 tons per annum; production in 1864, 24,000 tons.

No. 69.

SPRING HILL COAL COMPANY.

Spring Hill colliery: Allan Fisher's mines, in Sharp Mountain, above water level; production in 1865, 16,383 tons.

SWATARA DISTRICT.

No. 71.

RED MOUNTAIN COAL CO.

Near Tremont: Production in 1865, 1,710 tons.

No. 72.

BEAR MOUNTAIN MAMMOTH VEIN MUTUAL COAL CO.

J. A. Dutter's old place: On Primrose and Mammoth, above and below water level; steam-power, 200 horse; capacity, 20,000 tons per annum.

No. 73.

J. A. DUTTER & CO.

New place, near Donaldson: Production in 1865, 8,116 tons.

No. 74.

TREMONT COAL COMPANY.

(Formerly Etien & Lomison, near Donaldson.)

The Estate of this Company consists of 4,500 acres of land, near Turnout. They now operate three collieries—those formerly worked by C. Garretson, (See No. 68,) Etien & Lomison, and Horton's old place, near Donaldson. The veins available are the Primrose, 10 feet thick; Mammoth, 15 to 30 feet; Black Heath, 12 feet; Skidmore, 10 feet, and the intervening veins. Total steam-power, 205 horse. Shipments for 1865 credited to the former operators.

No. 75.

STROH COAL COMPANY.

New company: Production in 1865, 4,251 tons.

No. 79.

ECKERT & CO.

Good Spring Creek colliery: One mile west of Donaldson, on Mammoth, above and below water level; steam-power, 150 horse; capacity, 50,000 tons per annum; production in 1865, 25,213 tons.

No. 80.

MILLER, GRAEF & CO.

Three Lorberry collieries, on Lorberry Creek, above and below water level, on Mammoth: Steam-power, 300 horse; capacity, 150,000 tons per annum; production in 1865, 108,961 tons.

No. 81.

HENRY HEIL.

Two collieries west of Tremont, on Mammoth, Holmes and Primrose, above and below water level: Steam-power, 200 horse; production in 1865, 76,900 tons.

No. 83.

LORBERRY COAL COMPANY.

In Sharp Mountain, at Lorberry: Diagonal slope, 321 feet in length; angle forty degrees, on Mammoth; steam-power, 100 horse; new operation; production in 1865, 2,810 tons.

No. 84.

BROAD MOUNTAIN MAMMOTH VEIN MUTUAL COAL CO.

Two miles west of Tremont: Slope on Primrose, Mammoth, Skidmore and other veins; steam-power, 120 horse; new place.

LYKENS' VALLEY DISTRICT.

Nos. 87 and 88.

SHORT MOUNTAIN COAL CO.
FRANKLIN COAL CO.

Two collieries: Now consolidated under one company, below water level, on Buck Mountain vein; steam-power, 700 horse; production in 1865, 129,973 tons.

No. 89.

BEAR VALLEY COAL CO.

New operation: Tunnel to the Bear Valley coal, lower seams.

No. 90.

NORTH MOUNTAIN COAL CO.

New operation in Bear Valley: Lower coal seams.

No. 50.

WOLF CREEK DIAMOND COAL COMPANY.

Figure 216.

LOCAL NAMES.

S. Tracy.

Cockle.

Little Diamond.

Diamond.

Little Orchard.

Orchard.

Primrose.

South Vein.

Reese Davis.

Black Valley.

Petherick or Black Heath.

Buck Vein or

Skidmore.

Buck Mountain.

SECTION AT WOLF CREEK.

This Company is located on several of our most successful mines, including the "Diamond," Black Heath and Black Valley, formerly owned by Gideon Bast, Esq., and more recently by Geo. H. Potts & Co. Both of these parties realized handsome profits from their operations.

The coal-beds now worked by the Wolf Creek Diamond Coal Company, are the Diamond J, and the Mammoth E E E, here split in three seams, which is its normal condition west of Mine Hill Gap. Locally these splits are known as the "Reese Davis," "Black Valley," "Black Heath" or "Petherick."

On the next page will be found sections of the Diamond, Reese Davis, and Black Valley; the thicknes of workable coal in the two latter being respectively from 8 to 10 feet; the *benches*, as represented, being extremely solid and free from impurities. The Black Heath or Petherick (?) is not represented, but the thickness of available coal is about the same as in the Black Valley, or from 8 to 10 feet. It will thus appear that, though the Mammoth is here divided into three seams, the amount of coal is not thereby diminished. The usual size of the Mammoth is 25 feet, and the three or perhaps four seams into which it is divided at Wolf Creek ranges from 24 to 30 feet in the aggregate. We do not think this division is an injury, since the coal preserves its splendid appearance, and many experienced miners are of the opinion that more coal can be obtained from veins of moderate dimensions, than from excessive enlargements, when the respective thickness is compared; that is—three seams of 10 feet each will produce more available coal per acre than one of 30 feet thickness, and—unless the larger bed is favorable formed and stratified—with more economy.

These collieries are located about one mile north of Minersville, on the Herbine and Wolf Creek tracts principally, comprising about 1000 acres of land with a "run" of nearly two miles on the "strike" of the seams.

Figure 216.

No. 1 colliery is known as the "old white-ash;" No. 2, as the "Diamond red-ash;" No. 3, as the "new white-ash;" No. 4, as the "Black Valley old slope," and No. 5, as the "Black Valley new slope." The steam-power on these five collieries is about 500 horse, and their capacity 200,000 tons per annum.

The quality of the coal from these mines is excellent, and has always stood very high in market. The Diamond colliery on the Diamond vein produces red-ash, which is appropriately named "Diamond" from its rich and splendid appearance, while its combustion in grates and stoves is perfect. For the production of a glowing and genial fire, in the open grate particularly, there is no coal equal to the Anthracite red-ash, and none better than that produced from the Diamond bed, or J of our nomenclature.

Between this seam and the Reese Davis E, there are four or five workable beds or veins including the Orchards, which may be operated by tunnels from any one of the Wolf Creek collieries.

The Reese Davis is a pink-ash coal, which is rare for any portion of the Mammoth, but the coal thus finds a place between the extra red-ash and the white-ash coals, and has been found to answer an admirable purpose for generating steam quickly, and for all purposes where a great draught cannot be obtained. The Black Valley, Black Heath or Petherick are white-ash beds and constitute the lower divisions of the Mammoth, and answer every purpose for which the white-ash Anthracites are used, while the just celebrity of these coals in market is the best guarantee of their general availability and good character.

OFFICERS OF THE

WOLF CREEK DIAMOND COAL COMPANY.

PRESIDENT.

W. G. AUDENRIED.

EXECUTIVE COMMITTEE.

LEWIS AUDENRIED,
GEORGE H. POTTS,
J. ROMMEL.

SUPERINTENDENT.

GENL. J. K. SIGFRIED.

No. 67.

NEW BOSTON COAL COMPANY.

Fig. 217.

BROAD MOUNTAIN BASIN.

This magnificent basin of coal will be found fully described in Chapter XIII, from page 269 to 278. It is an isolated deposit, identical with the Anthracite coal formation, but disconnected from any of the grand divisions or fields forming the Anthracite regions. It is rather neater to the Mahanoy or Middle coal field, than to the First, or Southern Anthracite field, and partakes more of the general character of the Mahanoy basins and coal-beds, than of the Schuylkill region; but we cannot justly assign it to either, and have, therefore, considered and described it as a distinct formation, as we have the Lehigh Basins, which are similar in extent, and in the character of their beds and coals.

The transverse section given above illustrates the number and relative sizes of the coal-beds, and their minimum and maximum dips. The character and location of the extensive improvements now being erected are approximately given, and the general style of the works in progress for the full development of the basin.

It will be noticed that a slope is sunk on the Buck Mountain bed. This slope is of large dimensions, and is sunk 420 feet below water-level. At this depth, a tunne is driven from the Buck Mountain to the Mammoth, which will cut both (C) and the Skidmore. Each of these veins or beds is in good workable condition, the first being from six to seven feet in thickness, and the latter from nine to ten. The accompanying vertical section gives the relative dimensions of the coal-beds, their distances apart, and the total depth to the bottom of the basin.

It will be noticed that A, which is seldom found in workable size elsewhere, is here seven feet thick, and productive of good merchantable coal. B, or the Buck Mountain, is a fine bed, of 18 feet thickness, and the coal, thus far developed, is of the most splendid character, both in appearance and for general use; as a steam and furnace coal, it must ultimately become a great favorite in the market.

Fig. 218.

Fig. 219.

The Mammoth here, however, is the grand bed of the Anthracite regi and ranges as high as seventy feet thickness; is evenly deposited, with none of the imperfections ge rally attending the great enlargem of this magnificent bed. We g (Fig. 219) a section showing its dim sions and divisions, in which it will seen that the amount of *bone* and sl is very limited, compared with the of the vein.

The works now being erected by New Boston Coal Company on t basin, are of the most complete extensive character, being designed executed by George H. Potts, assis by his superintendent, J. Louden Bea while the massive and powerful gines required, aggregating 700 hor power, are built by George W. S der, of Pottsville. and promise to perfect models of mine machinery.

VERTICAL SECTION OF THE BROAD MOUNTAIN BASIN.

The slope, engines, and breaker, all estimated for the production 1,000 tons of coal per day, and we h no doubt but that double this amo might be produced from this *one sl* and mine, if desired, since twelve ga ways may be driven in the six seam coal here available, and entered by nels from the main slope on the Bu Mountain. It is designed to elevat *train of four cars* at once, which, arriving at the top of the slope, r by gravity *to* and *from* the top of breaker; and at the bottom of the sl it is so arranged that a train can always be in waiting. I thus evident that not only 1,000, but 2,000 tons per day be produced from this simple slope on the Buck Mountain b B, a section of which is here presented.

The estate of this Company, in the New Boston Basin, co prises about 1,600 acres of land, and runs on the "strike" the seams or veins a distance of three and a half miles, whi of course, gives the length which the gangways can "run" the same. The average width of the basin is about 2,000 feet, and the depth from 900 to 1,000 feet. The total thickness of the coal is about 100 feet, which will yield, under economical mining, nearly 150,000 tons per acre; but taking the average yield at the safe estimate of 100,000 tons per acre, a small amount of calculation will produce a vast array of figures as the

SECTION OF MAMMOTH AT NEW BOSTON, BROAD MOUNTAIN BASIN.

Fig. [illegible].

probable production of this property. We hesitate to make them, since the result would scarcely be credited.

The location of this basin is available to both the Philadelphia and New York markets. It is about five miles from the Broad Mountain and Mahanoy Railroad, which is a feeder of the Philadelphia and Reading Road, and now a branch of the same. The mines may be connected with this road on easy grades, if desired.

A road is, however, now in course of construction from the New Boston Mines to Delano, on the Lehigh and Mahanoy road—a distance of about eight miles—with easy grades. This branch puts the New Boston Mines in direct connection with New York by rail, with an advantage in grades and distance over the Mahanoy Region generally, and nearly on a par with the Hazleton Mines.

SECTION B, OR BUCK MOUNTAIN, IN THE NEW BOSTON OR BROAD MOUNTAIN BASIN.

OFFICERS OF THE

NEW BOSTON COAL COMPANY,

FOR 1865.

PRESIDENT,

ROBERT LENNOX KENNEDY.

TREASURER, &c.,

FRANKLIN H. DELANO.

DIRECTORS,

New York.	*Boston.*
R. L. KENNEDY,	JOHN M. FORBES,
GEO. TALBOT OLYPHANT,	GEO. B. UPTON.
GEO. H. POTTS,	
JOHN J. ASHTON, JR.,	
FRANLIN H. DELANO,	*Buffalo.*
EDWARD DELANO.	CHAS. F. WADSWORTH.

MARYLAND.

CUMBERLAND COAL REGION.

BARTON COAL COMPANY.

The location of this Coal Company is at Barton, in Alleghany County, Maryland, on the waters of the George's Creek, and in the celebrated Frostburg basin. The town of Barton is on the George's Creek Railroad, about four miles above its junction with the Baltimore and Ohio Railroad at Piedmont, (see map of the Cumberland Coal Region on page 332.)

Figure 221.

The mines of this Company are about two miles to the east of the town, and are opened in the face of a mountain, down which the coal is conveyed by a self-acting gravity plane of 1,500 feet in length. From the foot of this plane an excellent T Rail track of 7,400 feet in length leads to the dumping house, on the line of the George's Creek Railroad, at Barton. The mine cars are taken direct from the mines to the head of the plane by horses or mules, and from the bottom of the plane by locomotive power. The capacity of the Barton mines is from 60,000 to 100,000 tons per annum. The planes and outside fixtures are capable of doing a much larger business, and it seems to us that the addition of the adjoining Mt. Clare estate to the coal property of the Barton Company would be most desirable, since it would enable the Company to increase their productions largely, and would make their operations permanent and equal in production and value to the best Cumberland mines. The situation of this property and its availability for mining purposes, particularly in connection with the Barton mines and improvements, cannot fail to strike the observant and practical mining engineer with favorable impressions, as it did us, during our late visit. It would afford an excellent opportunity of opening the mines on the Mt. Clare tract in a systematic and permanent manner, which is more than we can say of any of the mines in the Cumberland Region. Though the coal is mined reasonably cheap, it can be produced at less cost, and much more coal can be obtained from the same area; while permanence, reliability and a constant large production may be secured.

At the Barton mines, the "Big Vein" (Mammoth E) is 14 feet thick, of which 10 feet is nearly a solid body of pure coal, easily mined and productive of a beautiful cubical coal, mostly lump. No coal can be mined cheaper than the Barton, and, under ordinary prices for labor, it is estimated that the marketable coal can be put on board the cars for fifty cents per ton on a business of 50,000 tons per annum and upwards.

Figure 222, which we give on next page, is an ideal section of the coal formation across the Frostburg basin, but represents the position of the Mammoth (E) and other coal seams pretty correctly. It will be noticed that the number of seams and their relative position agree closely with the coal-beds of the Anthracite measures.

A reference to our numerous sections, illustrating the Anthracite formations, will demonstrate clearly the identifications of the Frostburg "Big Vein," with the Anthracite Mammoth, or E of our nomenclature. The highest production per capita, per annum, at the Anthracite mines during 1865 was 300 tons, or about

one ton to each person employed about the mines for each working day. At the Broad Top mines the production is over 400 tons per annum, and the English production is about 500 tons per capita, per annum. Of the production of the Cumberland mines we have not sufficient date on which to make positive statements, but have sufficient to estimate it at nearly 500 tons per annum.

Figure 222.

TRANSVERSE SECTION, FROSTBURG BASIN.

a, a, level of the Potomac at the mouth of George's Creek; *b*, mouth of George's Creek; *A, B, C, D, E, F*, coal-seams; *c, c*, elevation. It will be noticed that George's Creek is the deepest part of the Frostburg basin.

The great size of the Mammoth—which is larger in the Frostburg basin than anywhere else, in the bituminous coal fields, when regular and in good condition—and the peculiar formation of its nearly horizontal strata, render it one of the most economical beds to mine with which we are familiar. No costly machinery for drainage, hoisting and preparing purposes are required, and the constant attending expenses of deep mines are avoided. There is, however, a great want of system and mining information manifest in all this region, and, while the coal is mined so cheaply, the coal mines are often ruined before half the coal is extracted—otherwise coal may be mined in the Frostburg basin with more economy than anywhere else in this country.

VIRGINIA.

THE NEW HAMPSHIRE AND BALTIMORE COAL COMPANY.

The mines of this Company are located in Hampshire County, Virginia, near the southwestern extremity of the Frostburg basin. The mines are opened in the side of a mountain, in common with nearly all the Cumberland collieries on the Big Vein, and the coal is conveyed to the foot by gravity planes.

Figure 223.

The coal, both of the Barton and the Hampshire mines, is beautiful and prepossessing in appearance, while in practical use it is the best Cumberland; for many purposes superior to the Anthracite, and for almost every purpose—except the manufacture of iron—the Cumberland coal is equal in effectiveness. The great increase of the Cumberland coal trade during 1855, of 245,499 tons in a business of 903,495 tons, while the Anthracite trade decreased to a considerable extent, seems to indicate a better appreciation of the value of the Cumberland coal.

A large consumption of bituminous coal will eventually become a necessity in this country, where we have 200,000 square miles of bituminous to 470 square miles of Anthracite coal. The natural increase in the consumption of coal in the United States will be much greater than the increase of the British coal trade, and the present century may witness a production of 100,000,000 tons per annum. It is now over 22,000,000, consequently we shall be forced to use bituminous coal for many purposes in which anthracite is now employed. Both invention and improvement are tending to such results, and even the richest bituminous coal can now be used raw in the production of pig iron, by the Seimen's process, with much economy.

BROAD TOP COAL FIELD.

SIX-MILE RUN COAL COMPANY.

CAPITAL, $600,000. SHARES, $20 EACH.

JOHN ROMMEL, JR., PHILADELPHIA, *President.*

THIS coal company is located on a magnificent coal estate of eleven hundred and eighty-six acres, in the heart of the now celebrated Broad Top coal field,—the whole tract being underlaid with the principal seams of the region, and estimated to contain 20,000,000 tons of available coal, the character of which needs no commendation. The estate is bounded on the north by Six-mile Run, and on the west and south by Shreeve Run; and, since all the coal lies above water level, it is thus available at many points for development, while the tract is extensive enough for the location of a great number of large collieries. At present only two, the Fulton and North Point, are in operation, with a capacity of from three hundred to three hundred and fifty tons per day; but the rapidly increasing demand for Broad Top coal will soon require the full development of this property.

The coal seams developed are the Fulton, Barnet, Cook, Twin and Spear, with an aggregate thickness of twenty-five feet of workable coal. All these are above water level: the cost of developing them is small, the mining improvements simple, and less than *one-tenth* the cost of those erected on deep mines, while the constant expense of heavy machinery is avoided. Each man employed will produce over four hundred tons of coal per annum, which is one hundred tons more than the average production in the anthracite region.

The development of the Broad Top coal field is of a comparatively recent date,—1856,—yet the increase of its coal trade is unprecedentedly great, and now exceeds 300,000 tons per annum, with a capacity of double that amount. There are many fine coal estates in this field, but we think there are none more promising than that of the *Six-mile Run Coal Company.*

PAY ROLL No. 1, FOR CARBON COLLIERY, FROM JANUARY 1st TO JANUARY 31st, 1866, INCLUSIVE.

NAMES.	Occupation.	Amount of work.	Price of work.	Amount earned.	Deductions during month.							Amount of deductions.	Balance from Roll 1.		Amount due.	Amount paid.	Balance to Roll 2.		SIGNATURE OR REMARKS.
					Store.	Rent.	Powder	Oil, &c.	Sundr's	Labor.	Cash.		Dr.	Cr.			Dr.	Cr.	
Wm. Jones.	Miner.	15 yards	$10 00	$150 00	...	$2 00	$10 00	$2 75	$1 25	$50 00	...	$66 00	...	75	$84 75	$80 00	...	$4 75	his Wm. ⋈ Jones. mark.
John Smith.	Miner.	50 cars.	1 00	50 00	$20 00	...	2 50	2 00	50	...	$5 00	30 00	25	...	29 75	30 00	25	...	John Smith.
Jas. Brown.	Laborer.	20 days.	2 00	40 00	...	...	...	...	...	...	...	...	...	$1 50	41 50	40 00	$1 50	...	James Brown.
Peter Black	Driver.	20 days.	1 00	20 00	15 00	2 00	...	...	...	...	5 00	22 00	...	...	...	...	2 00	...	his Peter ⋈ Black. mark.
Sam. Davis.	Engineer.	31 days.	2 50	77 50	...	...	...	...	...	...	...	...	...	...	77 50	75 00	...	2 50	Saml. Davis.
Etc.	Etc.																		
				$337 50	$35 00	$4 00	$12 50	$4 75	$1 75	$50 00	$10 00	$63 00	25	$2 25	$233 50	$225 00	$3 75	$7 25	

The above is a plain Pay-Roll, suitable for all, or most, colliery accounts. It presents, at a glance, the full monthly account of each person employed; and in connection with the Time Book, Monthly Expense Account, and Shipping Book, are the only permanent books which are required for colliery accounts proper. At many of the large Anthracite collieries, stores are kept by the proprietors, or parties authorized by the proprietors, in which the workmen can obtain their merchandise during the month. The "pay-day" is generally a week—but sometimes two weeks—later than the end of the month, in order to give time for the return of all the deductions, and the closing of accounts. At large collieries, where 500 workmen (more or less) are employed, the accounts require considerable time for adjustment and proof. We have only given a few illustrations above, but sufficient to convey a good idea of the form and manner in which Colliery Pay-Rolls are kept. The column for "Labor" is designed for miner's laborers. Sometimes these do not appear in the account, as the miners or contractors are responsible, but often these laborers deal in the store, and the accounts are then deducted from the contractors.

PRICE OF ANTHRACITE COAL.

Prepared by Wm. G. Neilson.

Price of Schuylkill White-Ash Lump, per ton of 2240 lbs., by the cargo at Philadelphia. Averaged monthly from weekly quotations in *Philadelphia Commercial List and Price Current.*

	Jan.	Feb.	March	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Av'g for year.
1829										7.50	7.50	7.25	7.42
1830	7.25	7.25	6.00	5.75	5.75	5.75	5.75	5.75	5.75	5.75			6.08
1831													
1832													
1833		6.00	6.00	5.50	5.25	5.25	5.25	5.25	5.18	4.88	4.88	4.88	
1834	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.87	4.50	4.84
1835	4.56	4.56	4.56	4.56	4.60	4.63	4.63	4.68	4.88	4.90	5.03	6.47	4.84
1836	7.70	7.44	7.31	6.58	5.38	5.50	5.50	6.19	6.41	6.50	7.13	8.05	6.64
1837	8.25	8.25	8.04	6.78	6.50	6.38	6.10	6.00	6.00	6.09	6.13	6.13	6.72
1838	6.13	5.91	5.28	5.25	5.16	5.13	5.13	5.13	5.10	5.00	5.00	5.00	5.27
1839	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
1840	5.00	5.00	5.00	5.00	5.00	4.63	4.63	4.63	4.66	4.95	5.06	5.34	4.91
1841	6.40	7.00	6.44	5.88	5.69	5.17	5.13	5.27	5.56	5.63	5.63	5.63	5.79
1842	5.63	5.56	5.06	4.38	4.03	3.88	3.83	3.60	3.56	3.51	3.56	3.56	4.18
1843				3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
1844	3.50	3.33	3.10	3.02	3.00	3.03	3.13	3.21	3.26	3.26	3.27	3.26	3.20
1845	3.26	3.26	3.27	3.31	3.31	3.31	3.44	3.44	3.59	3.74	3.76	3.81	3.46
1846	3.81	3.75	3.72	3.84	3.87	3.97	4.00	3.94	3.96	3.88	4.00	4.00	3.90
1847	3.88	3.81	3.81	3.81	3.60	3.63	3.69	3.83	3.95	3.88	3.88	3.88	3.80
1848	3.90	3.90	3.58	4.44	3.37	3.29	3.33	3.56	3.46	3.41	3.29	3.36	3.50
1849	3.36	3.36	3.45	3.62	3.62	3.86	3.88	3.81	3.75	3.69	3.57	3.50	3.62
1850	3.50	3.50	3.40	3.31	3.25	3.25	3.25	3.25	4.25	4.25	4.25	4.25	3.64
1851	4.28	4.13	3.56	3.31	3.10	3.00	3.00	3.05	3.17	3.20	3.25	3.00	3.34
1852	3.18	3.47	3.40	3.44	3.44	3.45	3.45	3.50	3.56	3.56	3.56	3.50	3.46
1853	3.42	3.44	3.45	3.47	3.47	3.47	3.47	3.64	4.03	4.19	4.19	4.10	3.70
1854	4.50	4.50	3.25	4.39	4.81	5.16	5.55	6.00	6.00	5.81	5.68	5.60	5.19
1855	5.60	5.28	4.53	4.50	4.60	4.45	4.28	4.19	4.19	4.19	4.15	4.06	4.49
1856	4.06	4.25	4.25	4.25	4.05	4.50	4.00	4.00	4.12	4.13	4.10	4.08	4.11
1857	3.92	3.92	3.92	3.89	3.85	3.85	3.88	3.87	3.85	3.82	3.82	3.82	3.87
1858	3.83	3.83	3.77	3.47	3.23	3.23	3.25	3.25	3.32	3.32	3.32	3 30	3.43
1859	3.28	3.38	3.34	3.20	3.20	3.20	3.20	3.20	3.19	3.20	3.34	3.29	3.25
1860	3.28	3.29	3.30	3.30	3.23	2.31	3.36	3.39	3.50	3.53	3.62	3.63	3.40
1861	3.63	3.63	3.50	3.24	3.22	3.29	3.37	3.40	3.35	3.33	3.33	3.33	3.39
1862	3.33	3.33	3.11	2.78	2.78	3.64	4.58	4.85	4.98	5.22	5.50	5.63	4.14
1863	5.38	5.25	4.63	4.75	5.50	5.80	6.25	6.50	6.75	7.25	7.50	7.13	6.06
1864	7.10	6.75	6.59	7.20	7.88	8.34	9.78	10.75	10.13	8.90	8.88	8.38	8.39
1865	8.38	8.38	8.63	8.10	6.75	6.25	6.03	6.50	8.32	8.93	8.81	8.25	7.86
1866	7.94	7.75											

NOTE.—We find no reliable date on which to found an extension of the above chart further back than 1829; but may note the price of coal, at intervals, from the commencement of the anthracite trade. Anthracite coal was sold at Marieta, on the Susquehanna, for blacksmith purposes, at $8 and $9 per ton, from 1810 to 1814. In Philadelphia the first Lehigh coal was sold to Messrs. White & Hazard in the spring of 1814 for $21 per ton; and in 1820 three hundred and sixty-five tons were sold for $8.50 per ton. From 1822 to 1824 the prices of Lehigh coal ranged from $8.40 to $10 per ton, and during 1826–27 the prices of Schuylkill coal ranged from $7 to $7.50 per ton.

The above table was prepared with much labor and care by Mr. Wm. G. Neilson, as a statistical chart for the use of the American Iron and Steel Association. He proposes to print it in four colors and handsomely mounted on rollers for reference. It will be issued in June.

SECTION IV.

STATISTICS OF PETROLEUM.

Rock-oil, or Petroleum, has so wonderfully and so suddenly assumed a prominent position among our mineral resources, for we can assign it no other position, that the statician has been unable to keep pace with the development; and, while the production has grown from little to much, at a rate beyond precedent, the demand and consumption has been equal. The increase of this trade is one of the wonders of the age. It reaches to almost every civilized city or country throughout the world. In almost every family, outside of the cities, it forces its way as the cheapest and most pleasing light that can be produced, except that from gas, and in all the trades and mechanical professions it has made a footing. Yet, within five years, it was hardly known as an article of commerce; but, within that brief time, it has become a leading article in the foreign trade of the United States. Though it has existed in the bowels of the earth for untold ages before the creation of man, and betrayed its presence by thousands of signs, in as many places, its availability was reserved for the present necessity,—the requirements of the present times.

The production of coal-oil and petroleum has become a permanent pursuit,—as much a business as the mining of coal, or the production of iron; and one that must continue to increase, but with more reliability and practical knowledge than in the past. While we are supposed to grow wiser and more skilled by experience and the aid of science, we appear to be less prudent and more excitable. The number of dupes who were fleeced by the oil speculation are legions; yet the smallest amount of prudence would have saved the "sharpest New Yorker," or the "smartest down Easter" from misfortune in courting the favors of the fickle goddess, called no more Fortune, but *Petrolea.*

A reckless trust to chance or luck was the governing principle a year ago, in making investments in oil stocks. No gambling could have been more precarious; because both Fortune and Mercury, the god of rogues, were to be waited on and trusted. More prudence and less haste might have saved $500,000,000 to the money bags of capital, but it would have been lost to the barren hills of Venango and the hungry speculator. While part of it has been sunk in bottomless oil wells to the vision of hapless stockholders, it nevertheless bore fruit, and has gone forth among the people, circulating from pocket to pocket, building cities, railroads and engines, and creating oil kings from the poor dwellers of those once despised barrens, now ycleped Petrolea.

Henceforth, perhaps, experience and practical skill may be made useful in seeking for oil; while science can, if put to the task, unravel many of the mysteries which now seal those deep fountains of oil and gas from the eye and mind of thousands, whose anxious ken would penetrate their secrets. But ordinary prudence will be sufficient, if practiced, to make the production of petroleum as certain and successful as the mining of coal, or the many mechanical pursuits of the day. Those who are willing to risk a few thousands, with the chance of realizing two or three hundred per cent., may still experiment, as they will, and with benefit to the country by new developments; but those who would invest in the business with the expectations of realizing a fair profit, will select their territory with great care, and sink

their wells with economy—persevering until rewarded. There is a wide field for the business,—from the Northwest of Pennsylvania to Eastern and Western Kentucky, if not farther,—and from the waters of the Alleghany and Ohio to within a hundred miles of the eastern escapemennt of the Alleghany mountains. Within this wide area, there are thousands of localities where oil may be found in paying quantities, and in all probability some spots as productive as Venango. Experienced oil men will not seek oil on the tops of mountains, nor expect to find much in the coal measures, above the mill-stone grit. But, within the territory mentioned, there are thousands of places, not yet developed, where oil can and will be found, with remuneration to the finder.

In Chapter XXX, on Petroleum, we gave our views on the peculiarities of rock-oil, and the ways and means of judging of its available existence. But we may add here, that the flow of gas from oil wells ought to be stopped or checked, if possible, both in the course of boring and afterwards; since there can be no doubt but that much of the *oil* escapes in this manner, while the gas is the motor to force up the oil, and without it a flowing well cannot exist.

Hundreds of abandoned wells are still emitting gases, and thus tapping the sources of supply and diminishing the ultimate production. When we say that more than half the oil escapes as gas, we are certainly within the fact, and can give no better illustration of the waste than to state that at least 3,000,000 barrels of oil are now escaping per annum as gas. We make this statement after a careful examination and a pretty careful estimate of the gaseous volume of hydrocarbon as compared with the fluid. Much of this waste can be checked by a careful stopping of all abandoned wells, by filling them, first with a wooden plug at the depth of a hundred feet, or more, and above that with pounded earth. The flow of gas may also be checked, in sinking wells, by several devices to fill the cavities; but perhaps the best plan, where the flow is great, will be to reduce the gas to oil by mechanical and chemical means,—a mode of accomplishing which has been patented by the writer.

PRODUCTION OF PETROLEUM.

The daily production of petroleum in Venango County is stated at 10,000 barrels for 1866, while the total production of Pennsylvania, Western Virginia and Kentucky is estimated by good judges to be about 12,000 barrels per day, or over 3,000,000 barrels per annum. In the two past years the figures are thus:

	Barrels.
Production of 1864	2,130,000
" 1865	2,232,878
Estimated for 1866	3,000,000

COMPARATIVE EXPORTS OF PETROLEUM.

From.	Gals. 1863.	Gals. 1864.	Gals. 1865.
New York	19,674,897	21,332,974	14,393,586
Philadelphia	4,939,708	7,760,148	12,714,585
Boston	2,048,720	1,096,307	1,438,978
Baltimore	1,003,833	929,971	973,117
Other places		142,261	100,000
	27,667,158	31,261,661	29,720,266

The exports during 1862 were 10,887,701 gallons.

We republish, from the *New York Shipping and Commercial List*, the exports from New York during 1864, and points of exports.

From New York	1864. Gals.	1865. Gals.
To Liverpool......	734,755	2,156,851
London.........	1,430,710	2,576,331
Glasgow, &c....	368,402	414,943
Bristol.........	29,124	71,912
Falmouth, Eng'd.	316,402	623,176
Grangemouth, England......		425,334
Cork, &c.......	3,310,362	1,532,257
Bowling, England	87,164	
Havre...	2,324,017	1,774,890
Marseilles......	1,982,075	1,167,893
Cette...........	4,800	
Dunkirk........	232,803	
Dieppe..... ...	79,581	46,000
Rouen..........		143,646
Antwerp.......	4,149,821	2,692,974
Bremen........	991,905	903,004
Amsterdam.....	77,041	436
Hamburg.......	1,186,080	1,466,155
Rotterdam......	532,926	757,249
Gottenburg.....	33,813	
Constadt	400,376	88,060
Cadiz & Malaga.	55,674	33,824
Tarragona and Alicante.....	16,823	33,000
Barcelona	25,500	
Gibralter.......	69,181	308,450
Oporto.........	17,474	2,339
Palermo........	7,988	57,115
Genoa & Leghorn	635,121	399,674
Trieste	165,175	3,000
Alexandria, Egy't	4,000	
To Lisbon	167.195	64,662
Canary Islands..	3,358	5,125
Madeira........		400
Bilboa..........	2,500	
China and East Indies.......	3,338	364,942
Africa	25,195	12,230
Australia.	377,894	304,166
Otago, N. Z.....	10,810	5,500
Sidney, N. S. W.	97,880	48,013
Brazil..........	149,676	160,152
Mexico.........	112,986	69,481
Cuba...........	418,034	256,436
Argentine Republic	20,260	24,470
Cisalpine Republic...........	78,552	117,626
Chili...........	96,550	66,550
Peru...........	169,061	256,407
British Honduras	6,072	440
British Guiana..	7,881	15,104
British West In's	70,976	60,931
British N. American colonies..	28,902	16,995
Danish West In's	8,463	31,503
Dutch West Ind's	26,638	12,143
French West In's	16,020	9,104
Hayti..........	7,088	12,064
Central America.	993	456
Venezuela......	28,583	15,455
New Granada...	56,490	107,837
Porto Rico......	20.026	59,439
Total gallons............	21,280,489	19,547,604

AVERAGE PRICES OF PETROLEUM IN 1864 AT NEW YORK AND PHILADELPHIA.*

	Crude. (per gallon.)	Refined. (per gallon.)
January.......	$31\frac{3}{16}$ cents.	$52\frac{3}{8}$ cents.
February......	$30\frac{1}{4}$ "	$55\frac{3}{4}$ "
March.........	$81\frac{1}{4}$ "	$59\frac{1}{2}$ "
April.........	$37\frac{8}{16}$ "	$64\frac{7}{16}$ "
May...........	38 "	$65\frac{1}{2}$ "
June	$44\frac{1}{2}$ "	77 "
July..........	$52\frac{1}{16}$ cents.	92 cents.
August	$52\frac{5}{8}$ "	$87\frac{3}{4}$ "
September	$46\frac{7}{16}$ "	$86\frac{3}{4}$ "
October	$40\frac{3}{8}$ "	$75\frac{3}{4}$ "
November.....	$45\frac{7}{16}$ "	$86\frac{1}{16}$ "
December	$52\frac{3}{8}$ "	$92\frac{6}{16}$ "
Average for 1864	41.81 "	74.61 "
Average for 1863	28.13 "	51.74 "

* From Erni's' Coal Oil and Petroleum.

Figure 224.

ST. CLAIR FURNACE.

JAMES LANIGAN, Proprietor, *Pottsville, Pa.*

This furnace was originally erected by Burd Patterson, Esq., for the purpose of using the ores of the Anthracite coal measures, but no proper or systematic effort has ever been made to mine them with economy, though they are equally as rich and available as the iron ores of the Welsh coal fields, and may, and will, yet be used in our Anthracite furnaces as the most judicious mixture for the more refractory magnetics.

The iron ores of our coal measures are chiefly the carbonates, with a small per centage of the carbonates of manganese, lime and magnesia. The amount of metallic iron ranges from thirty to sixty per cent. as an average. The cost of mining these ores in South Wales is about one dollar and fifty cents per ton, and the cost of calcining less than fifteen cents per ton. With miners' wages, at double the Welsh prices, our ores, yielding forty per cent., may be placed at the furnace for $2.50 per ton, which is much less than the cost of magnetic and hematetic ores, estimating a proportionate yield.

The iron ores of our coal measures, therefore, may be considered of immense future importance to the iron manufacturers of the Anthracite regions, since it is not only rich and accessible, but inexhaustible.

Over 10,000 tons of this ore, mined in the vicinity of the St. Clair furnace, were smelted at the Pioneer furnace, Pottsville, with the most excellent results, and the metal was sold for the production of hollow ware, at nearly double the price which common Anthracite pig then commanded.

A revolution is taking place in the iron and steel business, and the old tedious and costly processes are being overwhelmed by new, direct and economical methods

In a word, the pneumatic process is now fairly established, and it has been demonstrated beyond a doubt, that *steel* and *homogenous iron* can be made by this method with more economy than common puddled iron. These new processes can be put in operation at St. Clair with more economy and profit than almost any other part of this country, or perhaps the world. Coal is the largest item of the raw material in the elaboration of iron and steel to its useful forms, and here the best and purest coal is more available than elsewhere outside of the Anthracite regions. It requires from five to six tons of coal to produce a ton of iron or steel rails, while three tons only of ore and flux are required; consequently it is cheaper to convey the *ore* to the *coal* than the *coal* to the *ore*. But from one-third to one-half the ore may be obtained from the coal measures in the vicinity of the furnace with improvement to the "make;" therefore it is evident that iron and steel can be manufactured not only with economy at St. Clair, but they can be elaborated to the more useful forms with the maximum of profit, since coal is the great item in these operations, and here coal is plentiful, convenient and cheap. The facilities for transportation are equal to all the requirements; the markets, east and west, north and south, are open by the most direct routes, while the best bituminous coal of the Alleghanies is easily accessible over the Philadelphia and Erie Railroad *via* Sunbury and Shamokin, or Catawissa and Tamaqua. Bituminous coal is therefore more available at St. Clair than at Reading, or even at Harrisburg. In fact, there is no other locality where the general availabilities are superior; where the best furnace coals are more accessible, and no other place where the natural advantages of site, ground and building facilities, are more desirable for the manufacture of iron and steel than St. Clair.

LANING & MARSHALL,

Wilkesbarre, Luzerne Co., Pa.,

FOUNDERS, ENGINEERS, AND BOILER MAKERS,

MANUFACTURE EVERY DESCRIPTION OF HEAVY MACHINERY, INCLUDING

STEAM ENGINES

of all kinds, for shafts, slopes, planes, coal breakers, blast furnaces, and rolling mills.

CORNISH AND BULL PUMPING ENGINES,

double and single acting pumps of every variety, for mining and other purposes.

CHASSER MILLS,

for Powder making

Saw and Grist Mills, Railroad and Mine Cars, etc., etc.

FLUE, TUBULAR, AND CYLINDER BOILERS

of the best Pennsylvania charcoal iron. Fagoted and other forgings of all kinds, and

IRON & BRASS CASTINGS

of every description.

This establishment comprises tools of the largest capacity and most efficient character; also a great variety of patterns, drawings and plans, prepared for all kinds of machinery.

A. C. LANING. S. R. MARSHALL.

In our recent tour through the Coal regions we were pleased to notice the very efficient and substantial mining machinery erected by Messrs. Laning & Marshall, at many of the mines in the Wyoming valley, but particularly at the Baltimore Coal Company's and the Wilkesbarre Coal and Iron Company's new improvements. Also a magnificent Chasser Mill, at the Messrs. Dupont's Wapwallopen Powder mills,—each wheel of which weighs 15,000 pounds.

S. H. D.

A 50 HORSE-POWER BOILER.

SCALE: — ⅛ of an inch to the foot.

13 ft.

SIDE VIEW.

THE HARRISON STEAM BOILER.

The Patentee of this boiler says in his circular that "This new steam generator combines essential advantages; In *absolute safety from explosion*, in cheapness of first cost and cost of repairs, durability, economy of fuel, facility of cleaning and transportation, not possessed by any other boiler in use."

It is formed of a combination of cast-iron hollow spheres, each eight inches external diameter and three-eighths of an inch thick, connected by curved necks. These spheres are held together by wrought-iron bolts, with caps at the ends.

The form is the strongest possible; its strength to resist pressure very great, unweakened by punching or riveting, which lessens the strength of wrought-iron boilers about forty per cent. Every boiler is tested by hydraulic pressure at 400 lbs. to the square inch. *It cannot be burst under any practicable steam pressure.*

It is not affected by corrosion, which so soon destroys the wrought-iron boiler. More explosions being attributed to this cause than any other

It has economy of fuel equal to the very best boilers in use, arising from the large extent and nearness of its heating surface exposed to the direct action of the fire, as also from the waved line of its fire surface, which mixes the gases, breaks the flame, and thus absorbs the heat more effectually than the ordinary tubular or plate-iron boiler.

6 ft.

13 ft.

3 ft. 3 in.

FRONT VIEW.

It gets up steam quickly from cold water, and with little fuel. It produces very dry superheated steam, and is not liable to priming or foaming.

It is easily transported, can be erected by ordinary workmen, and is readily cleaned inside and out. Under ordinary circumstances it is kept free from permanent deposit by merely blowing the water entirely out under pressure, once a week. It requires no special skill in its management.

Injured parts can be renewed with great facility, as they are uniform in shape and size. The greater portion of the boiler will never need renewal. It can be increased to any extent, by simply adding to its width; and, being a multiplication of a single form, its strength remains the same.

It has less weight, and takes but one-half of the ground area of the ordinary boiler, without being increased in height.

Any kind of fuel may be used under this boiler, from waste coal-dust to the most costly.

As an evidence of the safety of this boiler, in one instance, by the accidental rupture of a water-pipe, entirely apart from the boiler, its whole contents were discharged, under a pressure greatly exceeding 100 lbs. to the square inch, an active fire being under the boiler at the time. Means were taken as soon as practicable to deaden the fires, but they were not drawn, and the boiler became, as a matter of course, most unduly heated.

Under these circumstances, and as soon as the ruptured pipe could be closed, the boiler was refilled suddenly with cold water, without giving it time to cool, steam was again raised, and all went on as before, the boiler sustaining no injury. It may be inferred what would have happened under the same circumstances with a wrought-iron boiler.

In writing to the *American Artisan*, Mr. Harrison speaks as follows of his boiler:

In your article headed "Another Steam Slaughter," [page 10 present volume of the *American Artisan*] alluding to boilers considered safe, mention is made of "the cast-iron boiler made by Mr. Harrison, of Philadelphia." You say "this boiler is safer than any used on boats; but cast-iron is liable to be strained by inequality of temperature, and therefore should not be preferred to wrought-iron for passenger vessels." Many years of experience in the use of this boiler has taught me that, as a material for steam boilers, cast-iron is far preferable to wrought-iron, and for a reason which can very easily be understood. Cast-iron is not "liable to be *strained* by inequality of temperature." It is liable to *break* by such cause, and will give out at once if badly proportioned or improperly used. *Wrought*-iron in steam boilers is "liable to be strained by inequality of temperature," and, not fracturing at once, goes on straining until its structure is destroyed, and then the parts thus strained inevitably give way—death and destruction too often following.

Put cast-iron into such a form as will prevent harm in case of rupture, and it becomes the best material for steam boilers. One of the best qualities lies in its giving way at once when badly treated—a warning not to treat it so again. In the peculiar form in which I put cast-iron—viz., hollow spheres—it is not broken or injuriously affected in any way by unequal expansion or "inequality of temperature." Not so wrought-iron; its very tenacity begetting a false security which may lead to disaster at any moment.

GLOSSARY.

Adit. Water-level; a drain.

Alpha. First anthracite coal-bed.

Anticlinal. Convex; like the roof of a house; strata dipping two ways.

Arenaceous. Sandy.

Argillaceous. Clayey.

Auroral. Rogers's second series of Palæozoic strata.

Axis. Lines of synclinal or anticlinal basins, or ridges.

Azoic. Without life; gneiss.

Basalt. A trap, or igneous rock.

Basin. A synclinal trough.

Benches. Layers or strata in a coal-seam.

Bitumen. Mineral pitch or tar.

Blackband. A rich carbonaceous iron-stone.

Black Damp. Carbonic acid.

Bloom. A lump of malleable iron.

Board-and-Wall. An improved mode of mining coal (much used in England).

Bogie. A small hand-car used in mines.

Breaker. A coal-cracker.

Breasts. A term applied to the chambers in which miners dig coal.

Breccia. Rock composed of angular fragments.

Bull Engine. Direct acting steam pumping-engine.

Cainozoic. Recent life; upper strata.

Calamite. A coal-plant or fossil.

Calcareous. Rock containing lime.

Carboniferous. Containing carbon.

Coave. Sled for transporting coal in mines.

Cracker. A coal-breaker.

Creep. Gradual crush in coal-mines,

Crop. Edge of the strata.

Damp. Heavy vapor; carbonic acid gas.

Denudation. Erosion of upper strata.

Devonian. Rocks between the Silurian and Carboniferous.

Dike. An intrusion of trap-rock

Dip. Inclination of strata.

Drill. A tool for boring a hole in rock or coal.

Dump. An apparatus for emptying cars.

Escarpment. Steep slope of a hill.

"Face." The working end of a gangway or breast.

Fault. Irregularity or dislocation of strata.

Ferruginous. Impregnated with iron.

Fire-Clay. A pure clay.

Fire-Damp. Carburetted hydrogen.

Formation. A stratum, or group of strata.

Fossil. Any relic of plant or animal in the earthy strata.

Furnace. For ventilating mines.

Gangway. The main avenues of a mine.

Geology. Doctrine of the earth.

Gneiss. A stratified granitoid rock.

Gossan. Oxidized outcrops of veins (a Cornish term).

Granite. A crystalline, unstratified rock.

Greenstone. An igneous trappean rock.

Gypsum. Plaster of Paris, or sulphate of lime.

Heading. Air-courses and cross-cuts in mines.

Hematite. Hydrated peroxide of iron.

Hornblende. A trappean or granitic rock.

Horseback. A roll or saddle in coal-mines.

Hypozoic. Under all life; the lower metamorphic.

Igneous. Unstratified rocks formed by heat.

"Intake." Downcast air-course.

Jurassic. A recent formation.

Laminated. Divided into thin layers.

Lepidodendron. A fossil plant (so named from the scale-like appearance of its leaf-scars.)

"Lift." A set of mine workings, or the distance water can be availably lifted by pumps.

Lignite. Wood-coal, or fossil wood.

Long-Wall. A mode of mining by which all or most of the coal is obtained.

Mesozoic. Middle life; one of the great divisions of fossiliferous strata.

Metamorphism. A transformation of strata by heat or chemical action.

"Mining, Under." The act of digging under coal or a soft strata in coal-seams.

Mollusca. A soft animal devoid of bones, but partly encased in shells.

Operator. An arbitrary term given to the anthracite coal miners and shippers.

Palæontology. Doctrine of ancient beings; the science of ancient or extinct animal or vegetable fossil remains.

Palæozoic. Ancient life; the most ancient or lowest great division of fossiliferous strata.

Pick. A tool for digging or breaking coal or rock.

Pillars. Coal left for supporting the roof in mines.

Porphyry. An igneous, volcanic rock.

"Post-and-Stall." The old English name for breast-and-pillar mode of mining coal.

Primal. The earliest Palæozoic strata of the Eastern Appalachian Basin.

Pyrites. A combination of sulphur with other minerals.

"Robbing." Term applied to pillar work,—as, "robbing back."

"Run." A mode of mining coal.

Schute. An incline or trough for sliding coal to the cars or shipping.

Seam. Thin layers of strata, especially coal-beds, which are erroneously called *veins* in the anthracite regions.

Section. Cut through; an actual or ideal exposure of any part of the earth's crust, showing the strata edgewise.

Shale. Argillaceous rocks split off in thin scales.

Silicious. Flint (applied to rocks containing silex or quartz).

Slate. Rocks which possess a regular cleavage.

Slope. A slanting shaft on the dip of a coal-bed.

Stratum,—plural, **Strata.** Any layer or group of sedimentary rocks.

Strike. The horizontal direction of strata.

Sump. An excavation at the bottom of a slope or shaft, from which the water from the mine is pumped to the surface.

Synclinal. A basin or trough formed by the "dip and rise" of the strata.

Trap, or Trappean. Volcanic rocks.

Upcast. Return air-course, through which the air or impurities ascend to the surface.

Vein. Minerals in fissures of the earth. The term is not applicable to coal-beds or sedimentary strata.

GENERAL INDEX OF SUBJECTS.

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